Supplementary Information

Title : Climate damages and adaptation potential across diverse sectors of the United States

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Comprehensive technical documentation describing the modeling framework, inputs, and limitations is publicly available.[1]

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1. Main Sources of Data for the Second Modeling Phase of the CIRA Project

Comprehensive technical documentation describing the CIRA2.0 modeling framework, inputs, and limitations is publicly available[2].

Additional data sources unique to each sectoral impact model are described and cited in the underlying literature for those applications (see Table 1 of the main paper and Table 3 of this Supplementary Information for references).

Sectoral impact data from the CIRA2.0 modeling project has been posted[3].

Metadata, results, and figures have been posted to the U.S. Global Change Information System[4].

Data Type	Description	Data Documentation and Availability
Carbon dioxide concentrations	Atmospheric carbon dioxide concentrations for RCP8.5 and RCP4.5.	Meinshausen, M., et al. The RCP Greenhouse Gas Concentrations and their extension from 1765va to 2500. *Climatic Change*, **109**, 213 (2011) doi: 10.1007/s10584-011-0156-z. Data available at: http://www.pik-potsdam.de/~mmalte/rcps/.
Bias-corrected and downscaled temperature and precipitation projections	Localized Constructed Analogs (LOCA) contain daily temperature (max and min) and precipitation data for a range of CMIP5 climate scenarios, baseline, and projection years.	U.S. Bureau of Reclamation, Climate Analytics Group, Climate Central, Lawrence Livermore National Laboratory, Santa Clara University, Scripps Institution of Oceanography, U.S. Army Corps of Engineers, and U.S. Geological Survey, 2016: Downscaled CMIP3 and CMIP5 Climate Projections: Release of Downscaled CMIP5 Climate Projections, Comparison with Preceding Information, and Summary of User Needs. Data available at: http://gdo-dcp.ucllnl.org/downscaled_cmip_projections/.
	The Scenarios Network for Alaska + Arctic Planning (SNAP) dataset contains bias-corrected and spatially downscaled temperature and precipitation projections for Alaska.	University of Alaska Fairbanks, SNAP: Scenarios Network for Alaska and Arctic Planning. International Arctic Research Center. Available online at: https://www.snap.uaf.edu/
Observed meteorology	Historical climate data for temperature, precipitation, and other weather variables.	Livneh, B., et al. A spatially comprehensive, hydrometeorological data set for Mexico, the U.S., and Southern Canada 1950-2013. **Scientific Data** 2, 150042 (2015). Available online at: https://data.nodc.noaa.gov/cgi-bin/iso?id=gov.noaa.nodc:0129374 Sheffield, J., G. Goteti, and E. F. Wood, 2006: Development of a 50-yr high-resolution global dataset of meteorological forcings for land surface modeling. *J. Climate*, **19**, 3088-3111 Global Meteorological Forcing Dataset for Land Surface Modeling. Available online at: http://hydrology.princeton.edu/data.pgf.php Smith, T.M., R.W. Reynolds, T.C. Peterson, and J. Lawrimore, 2008: Improvements NOAAs Historical Merged Land–Ocean Temp Analysis (1880–2006). *Journal of Climate*, **21**, 2283-2296. Data available at https://www.ncdc.noaa.gov/data-access/marineocean-data/extended-reconstructed-sea-surface-temperature-ersst-v3b

Sea surface temperature	Sea surface temperature data for near-shore areas (for coral reef and shellfish modeling).	Taylor, K.E., et al. An overview of CMIP5 and the experiment design. *Bull. Amer. Meteor. Soc.*, **93**, 485-498, (2012) doi:10.1175/BAMS-D-11-00094.1. Data available at: https://cmip.llnl.gov/cmip5/
Sea level rise and tide gauge levels	Sea level rise projections and tide gauge levels used to develop storm surge heights and probabilities	National Oceanographic and Atmospheric Administration. (2017). Global and regional sea level rise scenarios for the United States. NOAA Center for Operational Oceanographic Products and Services, Technical Report NOS CO-OPS 083.
Lightning strike projections	Change in lightning strikes across CONUS	Romps, D., et al. Projected Increase in Lightning Strikes in the United States Due to Global Warming. Science, 346(6211), 851-854 (2014).
Population and developed land projections	Median Variant Projection of the United Nation's (UN) 2015 *World Population Prospects* dataset used to project future U.S. population for 2015-2100.	United Nations, 2015: World Population Prospects: The 2015 Revision. United Nations, Department of Economic and Social Affairs, Population Division. Data available at: https://population.un.org/wpp/
	U.S. national and county-level population figures from 2000-2015	U.S. Census Bureau, cited 2017: Population Estimates Program. Available online at https://www.census.gov/programs-surveys/popest.html
	County-scale population and developed land projections from the Integrated Climate and Land-Use Scenarios model (version 2)	https://www.epa.gov/iclus EPA, 2017: Updates to the Demographic and Spatial Allocation Models to Produce Integrated Climate and Land Use Scenarios (ICLUS) (Version 2). U.S. Environmental Protection Agency, Washington, DC, EPA/600/R-16/366F. Available online at https://cfpub.epa.gov/ncea/iclus/recordisplay.cfm?deid=322479
Domestic economic growth	Projection of future gross domestic product from the Emissions Predictions and Policy Analysis (EPPA, v6) model. The projection of GDP growth through 2040 was taken from the 2016 Annual Energy Outlook reference case, combined with EPPA-6 baseline assumptions for other regions and time periods	Chen, Y.-H. H., et al. The MIT EPPA6 Model: Economic Growth, Energy Use, and Food Consumption. MIT Joint Program on the Science and Policy of Global Change, Report 278, Cambridge, MA (2015). Available online at http://globalchange.mit.edu/research/publications/2892 U.S. Energy Information Administration, 2016: Annual Energy Outlook. Available online at https://www.eia.gov/outlooks/aeo
Price deflator	Dollar years are adjusted to $2015 using the U.S. Bureau of Economic Affairs' Implicit Price Deflators for Gross Domestic Product, Table 1.1.9.	U.S. Bureau of Economic Affairs' Implicit Price Deflators for Gross Domestic Product, Table 1.1.9. See "National Income and Product Accounts Tables" at https://bea.gov/national/index.htm

2. Selection of Forcing Scenarios and Climate Models

As this second phase of the CIRA project was undertaken to inform the development of the Fourth National Climate Assessment (NCA4) of the United States Global Change Research Program (USGCRP), the selection of scenarios and projections has been made consistent, to the maximum extent possible, with the USGCRP-recommended inputs to the assessment. These inputs have the benefits of being well-known and commonly used by others in the climate change impacts modeling community.

This section describes the selected scenarios and projections, as well as details regarding how they were processed for use in the modeling framework.

2.1 Scenarios of GHG Emissions and Radiative Forcing

As described in the 2015 guidance from the USGCRP Scenarios and Interpretive Science Coordinating Group,[5] the NCA4 relied on climate scenarios generated for the Intergovernmental Panel on Climate Change's (IPCC's) Fifth Assessment Report (AR5). The scenarios are based on four "representative concentration pathways" (RCPs) that capture a range of plausible emission futures. The RCPs are identified by their approximate total radiative forcing (not emissions) in the year 2100, relative to 1750: 2.6 W/m^2 (RCP2.6), 4.5 W/m^2 (RCP4.5), 6.0 W/m^2 (RCP6.0), and 8.5 W/m^2 (RCP8.5). RCP8.5 implies a future with continued high emissions growth with limited efforts to reduce GHGs, whereas the other RCPs represent mitigation pathways of varying stringency; none of these scenarios represent any particular national or global policy, and are intended as illustrative scenarios for analysis.

As in many sectoral impact projects, the analyses presented in this paper use a comparative set of two RCPs due to computational, time, and resource constraints. Based on USGCRP guidance, the analyses utilize RCP8.5 as a high-end scenario and RCP4.5 as a low-end scenario. Comparing outcomes under RCP8.5 and RCP4.5 captures a range of uncertainties and plausible futures and provides perspectives on the potential differences between scenarios. Fig. 1 shows differences between RCP8.5 and RCP4.5 in terms of global GHG emissions and atmospheric CO_2 concentration. Under RCP8.5, global atmospheric CO_2 levels rise from current-day levels of approximately 400 up to 936 parts per million (ppm) by 2100 relative to the 1986–2005 average. Under the RCP4.5, atmospheric CO_2 levels at the end of the century remain below 550 ppm. For more information on RCP projections, see the USGCRP Climate Science Special Report (CSSR, 2017).[6]

2.2 Selection of Global Climate Model (GCM) Projections

To support development of the IPCC's AR5, over 20 climate modeling groups from around the world agreed to a coordinated climate modeling experiment called the fifth phase of the Coupled Model Intercomparison Project (CMIP5).[7] More than 60 models from these groups were run with the RCPs described above, and the resulting data archive has been made available for use by the scientific community over the past several years.

Statistical Downscaling

The results of these global climate model simulations are displayed in coarse geographic grid cells (roughly 2.5˚x2.0˚). This coarse spatial resolution can encompass disparate areas; for instance, a single grid cell of a global climate model can cover the distance from San Francisco to Sacramento. To provide more localized projections of climate changes—important for local impact assessment and adaptation planning—and to provide more consistency with historical observations, downscaling methodologies are typically employed. The approach used for this work is statistical downscaling, which develops statistical relationships between local climate variables (e.g., temperature or precipitation) and large-scale predictors (e.g., pressure fields), and applies those relationships to the GCM output. While many downscaled products using the CMIP5 archive are available, the modeling in this paper uses two of the highest-quality, publicly-available, and peer-reviewed downscaled primary datasets:

Contiguous United States: A 2016 dataset of downscaled CMIP5 climate projections was commissioned by the Bureau of Reclamation and Army Corps of Engineers and developed by the Scripps Institution of Oceanography with a number of collaborators.[8] This dataset, called LOCA (which stands for Localized Constructed Analogs), is used in USGCRP's CSSR, which provides the physical climate science basis for NCA4. The LOCA dataset has many advantages; notably, the statistical approach produces improved estimates of extremes, constructs a more realistic depiction of the spatial coherence of the downscaled field, and reduces the problem of producing too many light-precipitation days.[9] LOCA projections have been developed for both RCP8.5 and RCP4.5 using 32 GCMs from the CMIP5 archive. The LOCA dataset provides daily projections through 2100 at a 1/16th degree resolution for three variables: daily maximum temperature (tmax), daily minimum temperature (tmin), and daily precipitation. Some of the sectoral models presented in the current paper require additional variables, such as solar radiation, wind speed, and relative humidity, so a historical binning approach was employed to develop internally-consistent projections for these variables. Finally, the LOCA dataset has only been downscaled for the contiguous United States.

Alaska: The Scenarios Network for Alaska + Arctic Planning (SNAP), a part of the International Arctic Research Center at the University of Alaska Fairbanks, developed a downscaled climate dataset for Alaska,[10] which as described above, is not covered in the LOCA dataset. The commonly used SNAP dataset focuses on five climate models from the CMIP5 ensemble that have the most skill for Alaska and the Arctic.[11,12] These five models, all of which were run using RCP8.5 and RCP4.5, are: CCSM4, GFDL-CM3, GISS-E2-R, IPSL-CM5A-LR, and MRI-CGCM3.

While it would be preferable to use one downscaled product to maximize consistency, neither dataset covers all geographic areas needed for all analyses, and the strengths of each dataset offer significant advantages over other available downscaled products with broader spatial coverage.

Selection of GCMs

As in many sectoral impact analyses in the literature, the selection of a subset of GCMs is necessary due to computational, time, and resource constraints. Table 1 of this Supplementary Information presents the five GCMs that are used in the sectoral analyses of this paper, with the exception that analyses for Alaska used just two of these models. These five GCMs were chosen primarily based on their ability to capture variability in temperature and precipitation outcomes observed across the broader ensemble. While many different metrics could be used in this type of comparison, a logical and accepted approach is to compare the projections from CMIP5 CGMs for annual and seasonal temperature and precipitation.

Figs. 2, 3, and 4 show the variability across the CMIP5 ensemble for projected changes (2071-2100 compared to 1976-2005 baseline) in annual and seasonal (primarily summertime) temperature and precipitation across the contiguous United States. As shown, the five selected GCMs (CCSM4, GISS-E2-R, CanESM2, HadGEM2-ES, and MIROC5) cover a large range of the variability across the entire ensemble in terms of annual and season temperature and precipitation.

Fig. 5 presents the change in mean temperature across the lower 48 states (averaged across the five LOCA GCMs), and across Alaska (averaged across the two SNAP GCMs that are also included in the LOCA set – CCSM4 and GISS-E2-R). As shown, the models project significant warming by the end of the century under RCP8.5 compared to RCP4.5, particularly in parts of the Northeast, Midwest, and Northern Plains of the contiguous U.S. In Alaska, the projected temperature increase is highest along the North Slope, and the increase under RCP8.5 is significantly higher than that under RCP4.5.

Fig. 7 presents the percent change in mean annual precipitation across the lower 48 states and Alaska. As shown, the models project significant changes in precipitation by the end of the century under RCP8.5 compared to RCP4.5. Some regions, particularly the Southwest of the contiguous United States, are projected to receive less annual rainfall while other regions, particularly the Northwest, receive more annual rainfall. In Alaska, the projected increase in precipitation is generally highest in the eastern parts of the state, but the projections under RCP8.5 for the end of the century show extreme wetting across the majority of the state.

The selection of GCMs for this study balances the range alongside considerations of model independence, broader usage by the scientific community, and skill, which are described in the next section. The CMIP5 models vary in their ability to resolve certain climate system processes, including those most relevant to the United States. In addition, while over 60 different GCMs are represented, a number of the models share computer code or are parametrized in similar ways. Recent studies[13,14,15] provide analysis of both model skill at the global scale and independence of underlying code. These criteria were considered in the selection process.

With insufficient resources to conduct a country-specific weighting analysis based on skill and independence, a qualitative consideration of these metrics is still valuable. For purposes of this project, the five GCMs selected were developed by different, well-known modeling groups whose models are frequently used in the literature. In addition, two of the GCMs (CCSM4, GISS-E2-R) are developed by domestically-based modeling groups (NCAR and NASA, respectively). There is some expectation that modeling teams may pay closer attention to the regional climate in the region where the team is based, and that therefore domestically-based modeling groups might have comparatively greater skill for purposes of impacts analysis in the United States.

2.3 Selection of Sea Level Rise Scenarios

This modeling framework uses sea level rise scenarios described in a recent sea level rise technical report developed for NCA4[16] and the Climate Science Special Report of the USGCRP.[17] The global mean sea level rise estimates underlying these scenarios are based on the rates from the empirical literature.[18]

To generate the global mean sea level rises estimates, the projections are stratified based on rates in 2100, and the median for each subset of projections was identified to be consistent with the 2100 global mean sea levels. These medians represent projections in which global mean sea level rise in 2100 is 28-32 cm, 48-52 cm, 98-102 cm, 145-155 cm, 195-205 cm, or 245-255 cm. These six values of global mean sea level change in 2100 are shown in the first column of Table 2 of this Supplementary Information. After developing annual time series consistent with these 2100 sea levels, these projections are used in the Coastal Property analysis described in the main paper. To account for the differences in probabilities that each sea level trajectory could occur under each RCP, scenarios weights are then applied to the Coastal Property sector results for each of the six levels (Table 2).

Projections of location-specific differences in relative (or local) sea level change are used to account for land uplift or subsidence, oceanographic effects, and responses of the geoid and the lithosphere to shrinking land ice. Mean values for each tide gauge location are used, along with a distance weighting procedure for interpolating between tide gauge locations to attribute tide gauge-level results to each coastal county.

3. Comparison of Results to Previous Studies

3.1 Comparison of CIRA1.0 and CIRA2.0

The results presented in this "CIRA2.0" analysis build off the CIRA framework developed for the 2015 CIRA report *Climate Change in the United States: Benefits of Global Action*,[19] referred to as "CIRA1.0". The CIRA modeling framework was updated to be consistent with USGCRP-recommended modeling guidelines, such that these results would serve as inputs to NCA4. As a result of using different GCMs, different scenario frameworks, and alternative or enhanced methodologies for some sectors, the direct comparisons of results can be complex. For a detailed comparison of the two modeling frameworks, see Table 2.1 of the technical documentation for the CIRA2.0 modeling project.[20] The primary difference between the two modeling frameworks is the use of climate projection datasets. CIRA1.0 used emission scenarios developed specifically for climate impacts and benefits analysis – a business as usual scenario with a GHG radiative forcing of 8.6 W/m^2, and a global GHG mitigation scenario with a radiative forcing of 3.2 W/m^2, limiting the increase in global mean temperature to 2°C by 2100. These two scenarios were simulated in two GCMs, which after statistical downscaling, had different climate futures for the United States (hotter/dryer, cooler/wetter). As described in Sections 2.1 and 2.2 above, the CIRA2.0 framework used CMIP5 GCM projections under the RCP scenario framework, which were then statistically downscaled using the LOCA approach. The two CIRA modeling frameworks used different, but comparable, scenarios for sea level rise, population change, and economic growth.

3.2 Select Comparisons of Sectoral Results to Findings of Previous Studies

This section provides several brief comparisons between sectoral impact results reported in this paper to those found in recent literature.

<u>Labor</u>

The results presented in Figs. 1.C and 2 of the main paper and Tables 4-8 of this Supplementary Information show large projected impacts to labor from changes in extreme temperatures, as well as a significant difference between RCP8.5 and RCP4.5 on both changes in hours worked and wages for high-risk industries by the end of the century. The Southeast and the Midwest are particularly vulnerable to future labor productivity losses, where losses of high-risk labor hours up to 6.5% are estimated for some counties. A similar study of climate change impacts on labor also found that increasingly extreme heat across the nation—especially in the Southwest, Southeast, and Upper Midwest—threatens productivity, by more than 3% annually (in lost hours in high-risk industries) by late century.[21,22]

<u>Coastal Property</u>

As shown in Table 2 of the main paper, cumulative damages to coastal property under RCP8.5 and assuming no adaptation are estimated at $990 billion through 2100 (discounted at 3%), compared to $100 billion in the scenario where cost-effective adaptation measures are implemented. Under RCP4.5, costs without adaptation are estimated at $910 billion through 2100, compared to $87 billion with adaptation. Assuming no protective measure are taken, a previous study[23] found that $66-106 billion worth of current coastal property will likely be below mean sea level by 2050 under RCP8.5 ($62-85 billion under RCP4.5), which could grow to $238-507 billion by 2100 ($175-339 billion under RCP4.5). Values from the American Climate Prospectus presented are undiscounted, at 2011 property prices, using mean sea level measures, while the findings of this paper are based on mean high water levels and using projected property prices that grow with changes in the economy. Other recent research[24] found that annual hurricane damages to coastal development, considering both flooding and wind damages, currently amount to approximately $28 billion, but that by 2075, the figure could reach approximately $39 billion.

Electricity Demand

At the national level, the two electric power system models (ReEDS and GCAM) simulated in the current study estimate that the HDD/CDD changes result in average increases in electricity demand of 2.9% and 2.4%, respectively in 2050 under RCP8.5 (Fig. 10 of this Supplementary Information). Under RCP4.5, average change in demand in 2050 increases across both models by 2.0% and 1.7%, respectively. The results are also consistent with another recent national-scale study,[25] which found that average electricity demand in the residential and commercial sectors increase by 2.3-4.9% by 2050 under RCP8.5 and 1.2-4.1% under RCP4.5.

Road Infrastructure

In this study, climate change impacts on road infrastructure are projected to result in annual damages of $9.5 billion and $20.0 billion under RCP8.5 in 2050 and 2090, respectively. Under RCP4.5, projected damages are $6.5 billion and $8.1 billion, respectively. These values are of similar magnitude to those from a previous study[26], noting differences between the target years for analysis and the climate projections employed in each study. This other study found that climate change is estimated to add approximately $13.6, $19.0, and $21.8 billion to pavement costs by 2010, 2040, and 2070 (respectively) under RCP4.5, increasing to 14.5, $26.3, and $35.8 for RCP8.5.

As described in the main text of our paper, Table 2 presents the change in costs (relative to a reference period) under scenarios assuming reactive and proactive adaptation. For paved roads, proactive adaptation reduces temperature-related costs under both RCPs, and reduces precipitation-related costs. For gravel and unpaved roads, precipitation-related costs are higher with proactive adaptation than with reactive adaptation. This is because the options for proactively adapting unpaved roads to increased precipitation risks are limited to upgrading the roads to paved or gravel, which are both very expensive. Proactive adaptation for gravel roads is also very expensive, as it essentially involves reconstructing the road with enhanced structural capacity. Costs associated with the freeze-thaw stressor do not change significantly between the reactive and proactive adaptation scenarios.

Agriculture

For all major crops, with the exception of wheat, this study projects that unmitigated climate change under RCP8.5 will result in lower yields by the end of the century compared to reference yield rates (Supplementary Fig. 12; though cotton yields are higher than the reference until just before the end of the century). Importantly, the projected magnitude of this effect increases with time, suggesting that higher levels of climate change increase the adverse effects to crop yields. Yields under RCP4.5 decline relative to the reference period for most crops, except for cotton, wheat, and sorghum. With the exception of hay and wheat, projected yields under RCP4.5 show smaller declines compared to those estimated for the higher forcing scenario. Compared to RCP8.5, RCP4.5 is projected to have a significantly smaller negative effect on the future yields of barley, corn, cotton, and rice. These yield projections are generally consistent with findings of another recent domestic analysis, which found that wheat experiences yield increases due to climate change relative to their reference levels, while corn, soybeans, and silage decline across the length of the century.[27] However, as with most crop yield studies, estimated yields vary by region, based on the timing and magnitude of projected changes in temperature and precipitation and assumptions regarding carbon dioxide fertilization. Importantly, crop model inter-comparisons have shown that projected changes in yield can vary considerably due to structural uncertainties, and grow more variable over space and time.[28]

As for economic effects, this study finds that changes in crop prices and the level of production and consumption of agricultural products have important implications for the economic welfare of consumers and commodity producers. Projected losses in total economic welfare under RCP8.5 are $8.0 ($6.7-11) million in 2050 and $12 ($11-13) million in 2090; and under RCP4.5, $7.7 ($6.4-10) million in 2050 and $11 ($9.3-13) million in 2090 (Supplementary Table 5). These relatively modest economic effects compared to other sectors are explained by:

1) The crop modeling underlying this analysis did not simulate the adverse effects from pests, disease, and ozone, and damage due to changes in the occurrence of storms, such as flooding, tornadoes, and hurricanes. Inclusion of these impacts on crop yields would likely result in larger adverse effects from climate change.
2) Decreases in crop yield and the resulting price increases result in cumulative gains in producer surplus through the end of the century. However, declines in projected consumer surplus are slightly larger than the increases in producer surplus, resulting in modest net negative welfare effects overall.
3) The economic model used in this analysis, FASOM-GHG, FASOM-GHG simulates future potential landowner decisions regarding crop mix and production practices, and projects the allocation of land over time to competing activities in the agricultural sector (in a way that maximizes consumer and producer surplus) and the associated impacts on commodity markets. Because of this dual focus on consumer and producer surplus, the net effects of climate impacts tend to be more modest[29] than if only one type of welfare was considered.

3.3 Additional Discussion on the Treatment of Adaptation in Impacts Modeling

Adaptation, along with substantial and sustained reductions in global GHG emissions, has the potential to limit climate change risks and reduce society's vulnerability to climate change impacts.[30] There are a wide range of adaptation options that can vary depending on the sector, the timing of implementation, and other factors. For example, adaptation can be a reactive response (i.e., implemented in response to climate change impacts that have already occurred) or proactive (i.e., planned and implemented in anticipation of future climate change risks). Adaptation options may be undertaken by different actors (e.g., households, private sector, governments) and at various geographic scales (local, national, and international).

Within the CIRA2.0 framework, the sector-by-sector modeling of adaptation takes different forms, and the analytical approaches used to evaluate costs and effects of adaptation on reducing climate change impacts vary across the impact categories (Table 1 of the main paper). Some approaches have a strong focus on structural- and technology-based adaptation options (e.g., infrastructure maintenance and upgrades). Other forms of adaptation, including behavioral or market adjustments, are endogenously represented in many of the models to minimize climate change impacts without deliberate interventions, such as crop switching and changes in planting dates in response to shifts in climate conditions and irrigation availability, or increased electricity consumption for air conditioning in response to higher temperatures. Autonomous ecological adaptation is also assumed and modeled in a number of the ecosystem sectors, such as shifting distributions of freshwater fisheries (and the recreation they support) in response to changes in suitable habitat, or vegetation changes that in turn affect wildfire activity and associated response costs. In these cases, this autonomous adaptation is embedded in the analyses and the estimated damages reflect assumptions of behavioral, market, or ecological adjustments that take place without deliberate interventions.

Importantly, adaptation is not relevant to, or even possible, in some sectors. In addition, the reported benefits of adaptation for infrastructure sectors (Table 2 of the main paper) are not necessarily generalizable to other sectors.

4. Figures of the Supplementary Information

Figure 1: Global GHG emissions and atmospheric CO_2 concentrations for RCP8.5 and RCP4.5[31]

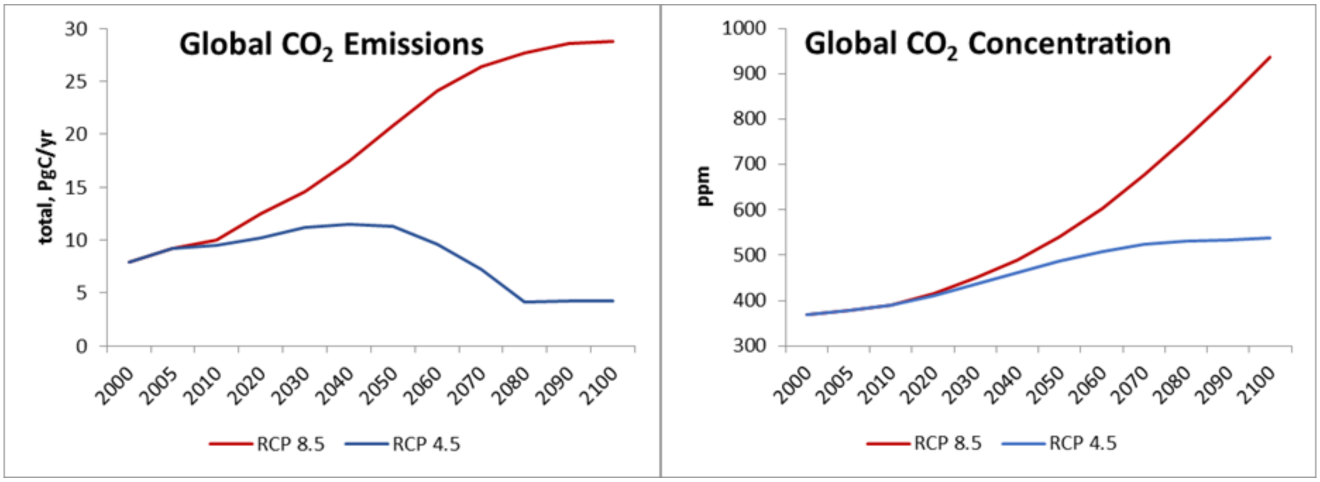


Figure 2: Variability of projected annual temperature and precipitation change across the CMIP5 ensemble for the contiguous United States

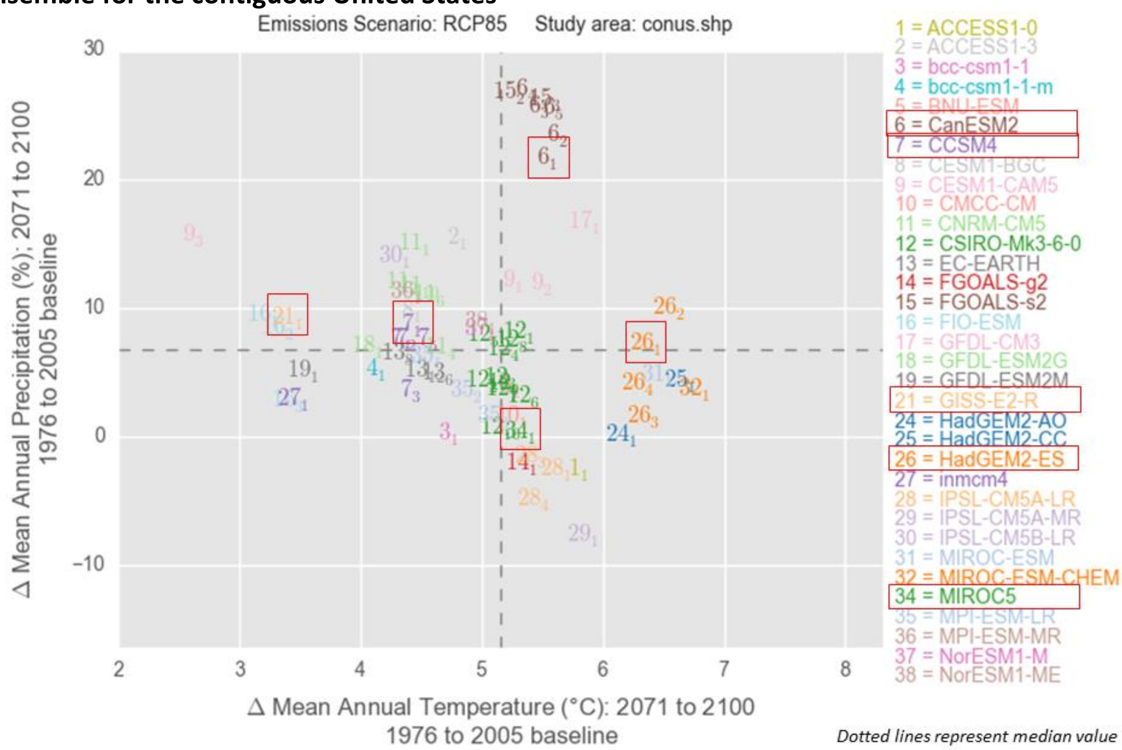


Figure 3: Variability of projected summertime temperature and precipitation change across the CMIP5 ensemble for the contiguous United States

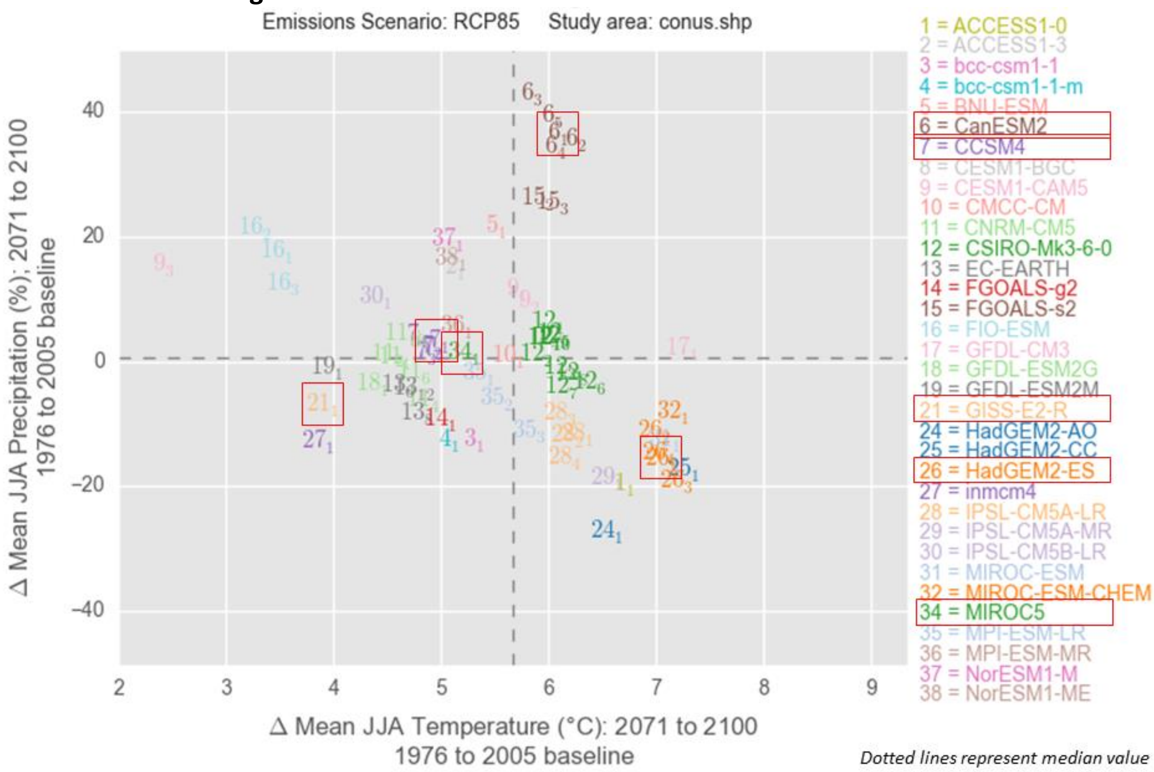


Figure 4: Variability of projected wintertime temperature and precipitation change across the CMIP5 ensemble for the contiguous United States

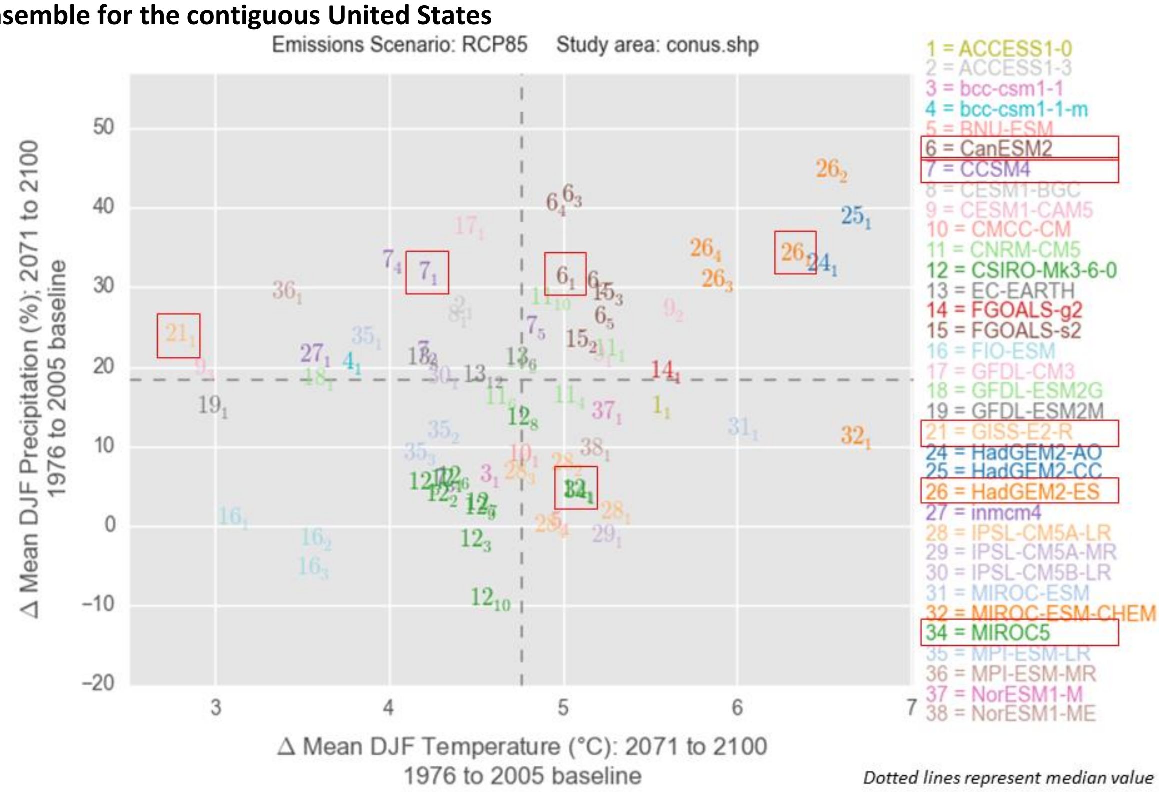
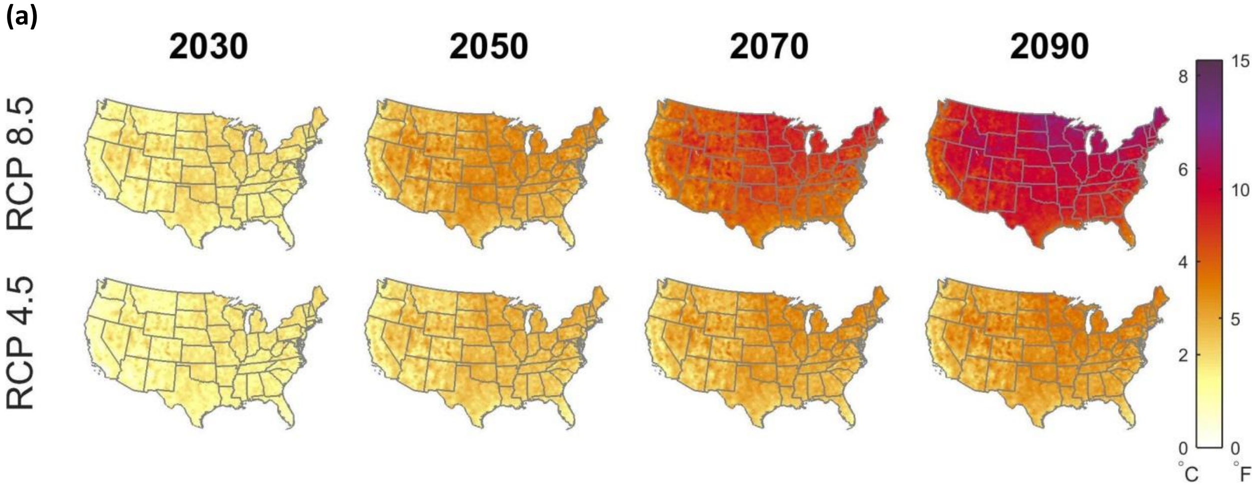


Figure 5: Projected change in mean annual temperature

Changes relative to the reference period (1986-2005) across (a) the contiguous United States (average across the five LOCA GCMs) and (b) Alaska (average across two SNAP GCMs)

(a)



(b)

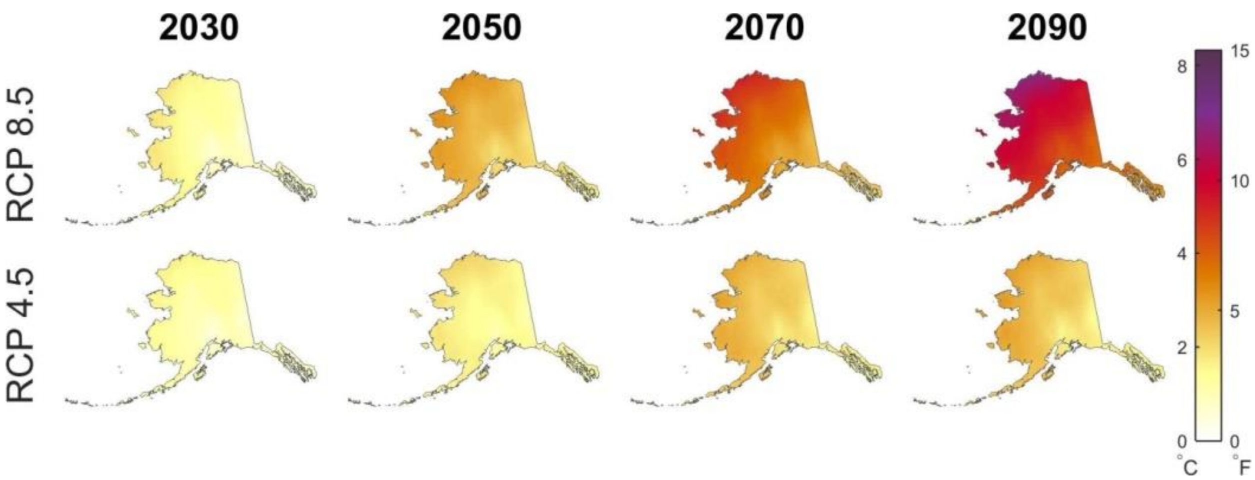
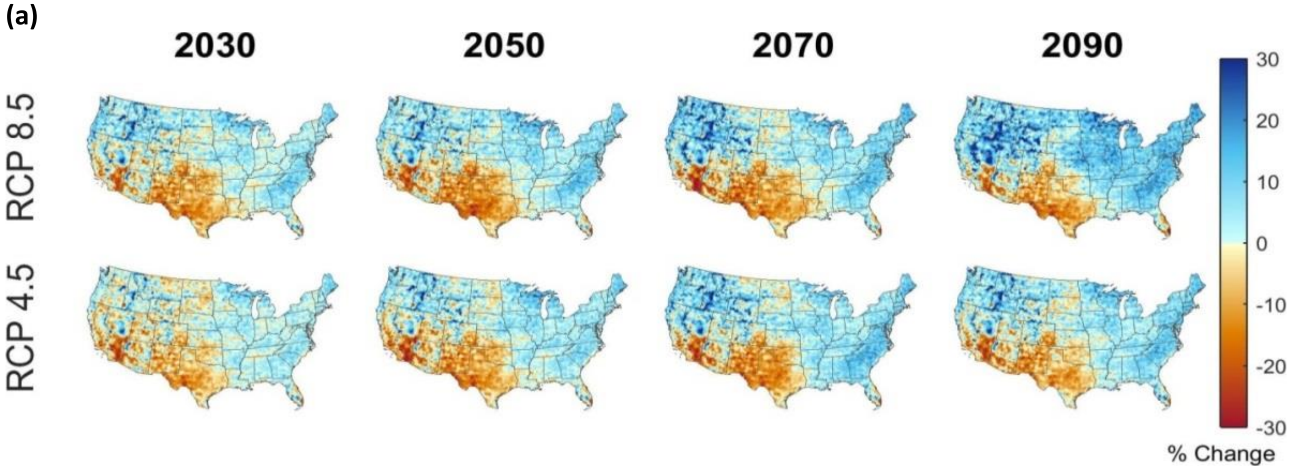


Figure 6: Percent change in mean annual precipitation

Projected percent change from reference period (1986-2005) across (a) the contiguous United States (average across the five LOCA GCMs) and (b) Alaska (average across two SNAP GCMs)

(a)



(b)

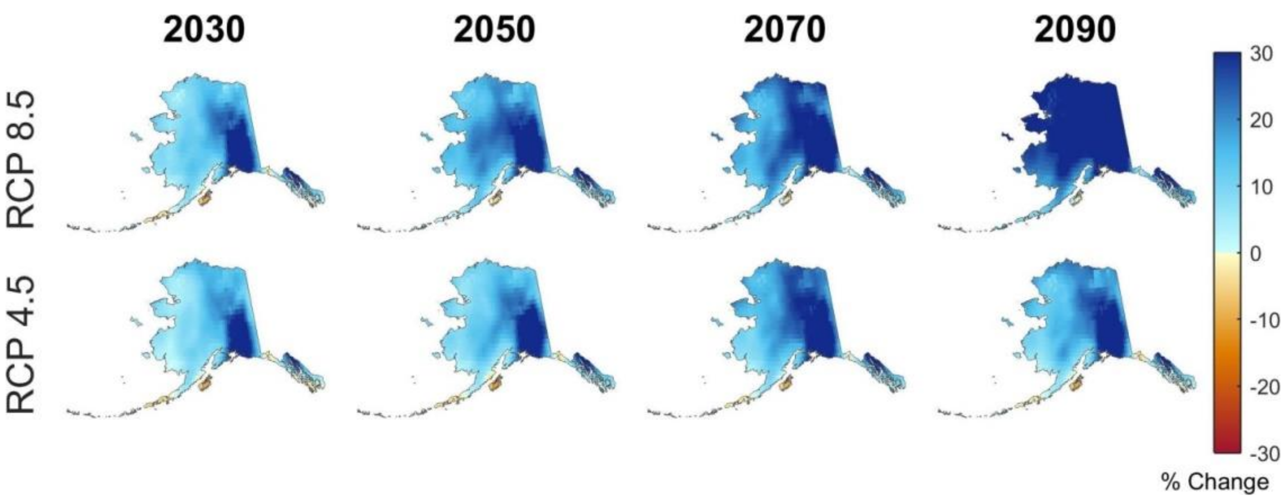


Figure 7: Absolute and percent change in projected county-scale population change in 2050 and 2090
Changes in county-scale population are included in the sectoral impacts modeling framework for applicable sectors.

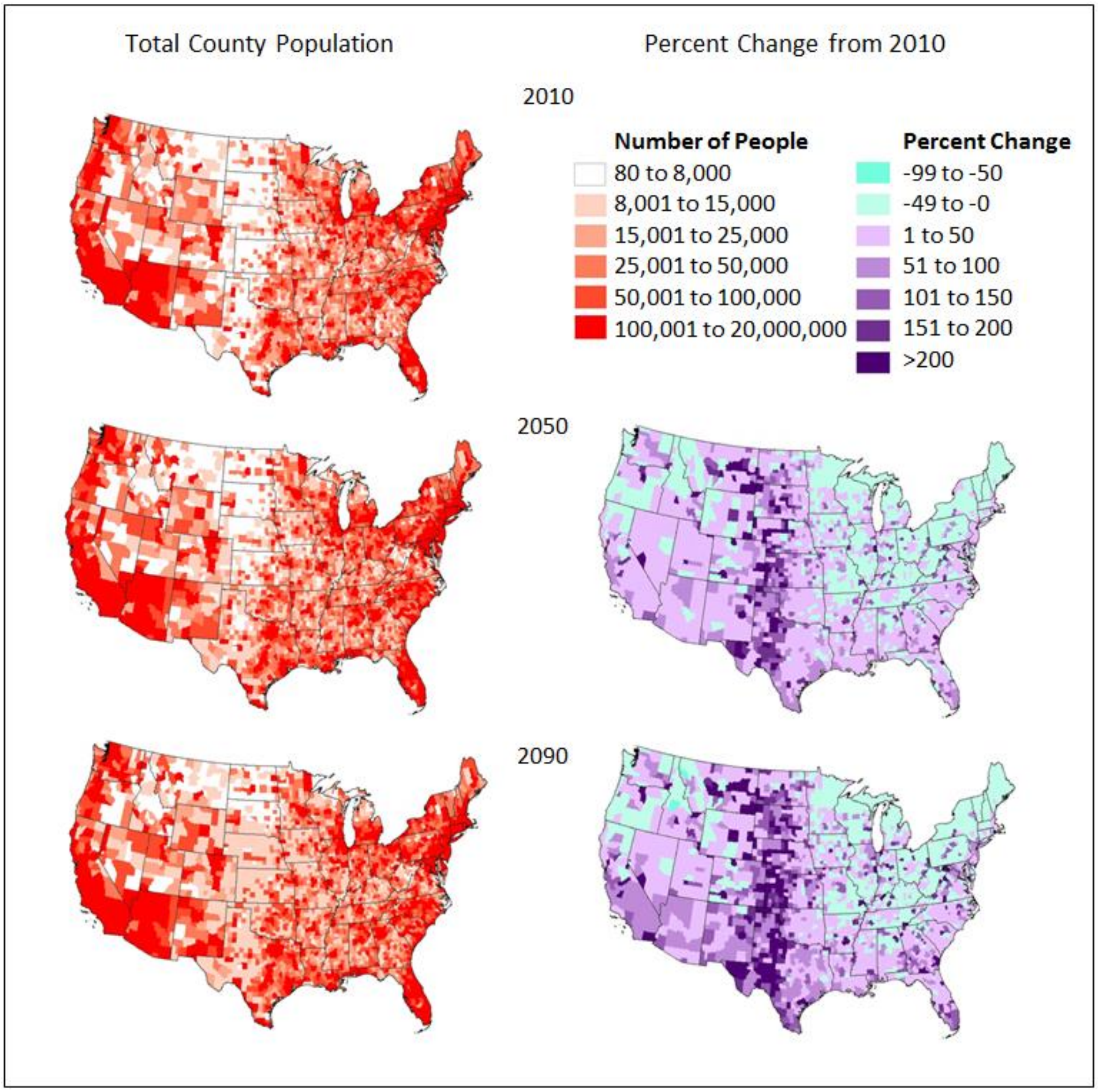


Figure 8: Projected gross domestic product from the EPPA model
Projected economic growth of the United States is used as an input to a number of sectoral impact models (e.g., to scale the value of a statistical life, or increases in coastal property value).

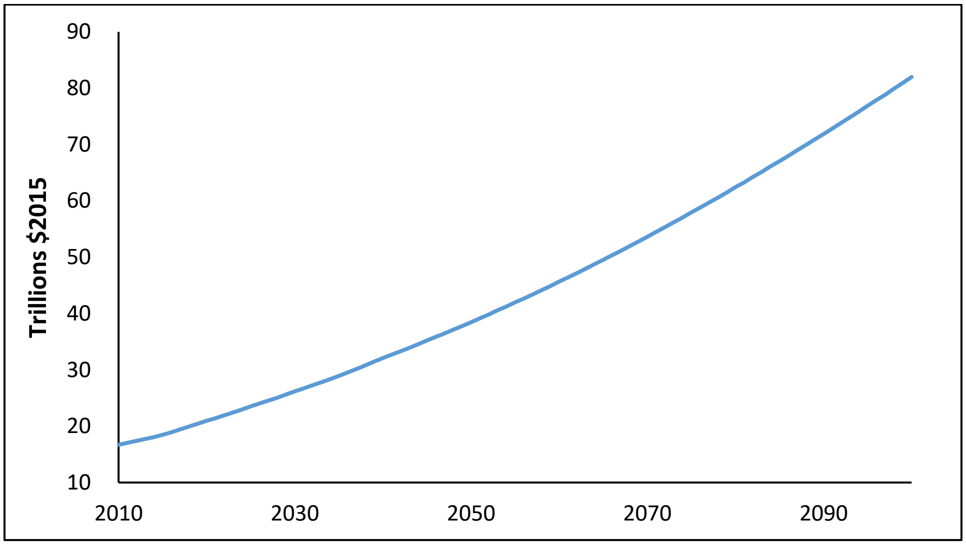


Figure 9: Comparing projections under the HAWQS and USBasins water quality impact models[32]
Projected changes in mean Water Quality Index values for 2050 (2040-2059) and 2090 (2080-2099) relative to the reference period (1986-2005) across the contiguous U.S. The results are averages across the five GCMs, and are aggregated to the Level-III Ecoregions. For reference, the water quality index is based on a 100-point scale.

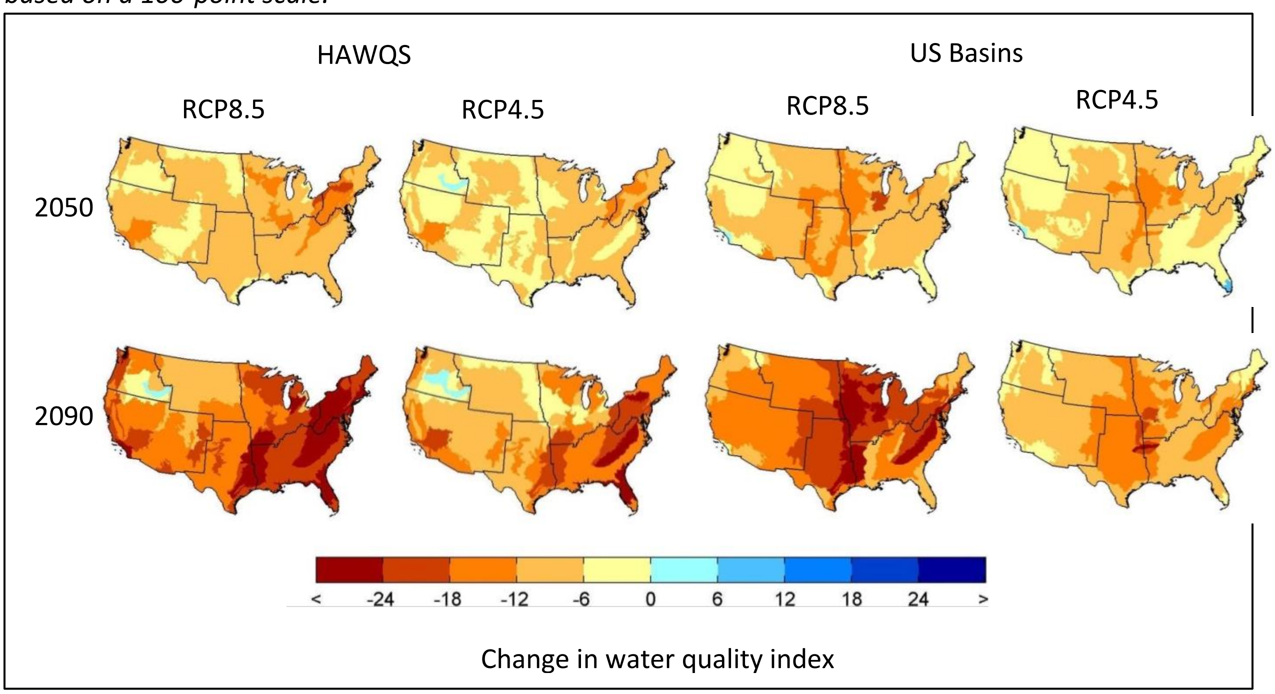


Figure 10: Projected number of 100-Year floods in the contiguous United States

In each plot, black dots are the median value across the five GCMs throughout the contiguous United States in each year of the 21st century, thick blue bars are the middle 50% of models, whiskers extend to the 95th percentile of values, and dots represent outliers. Thick black lines are five-year moving averages across all models. The annual number of 100-year floods across the contiguous United States across all five GCMs averages approximately 500 events from 2000-2020. This average number of floods increases substantially to approximately 1,300 events per year by 2100 under RCP8.5. Further information on the inland flooding methodology[33] and county-level projections in 2050 and 2090[34] (as in Fig. 1 panel K of the main manuscript) is available.

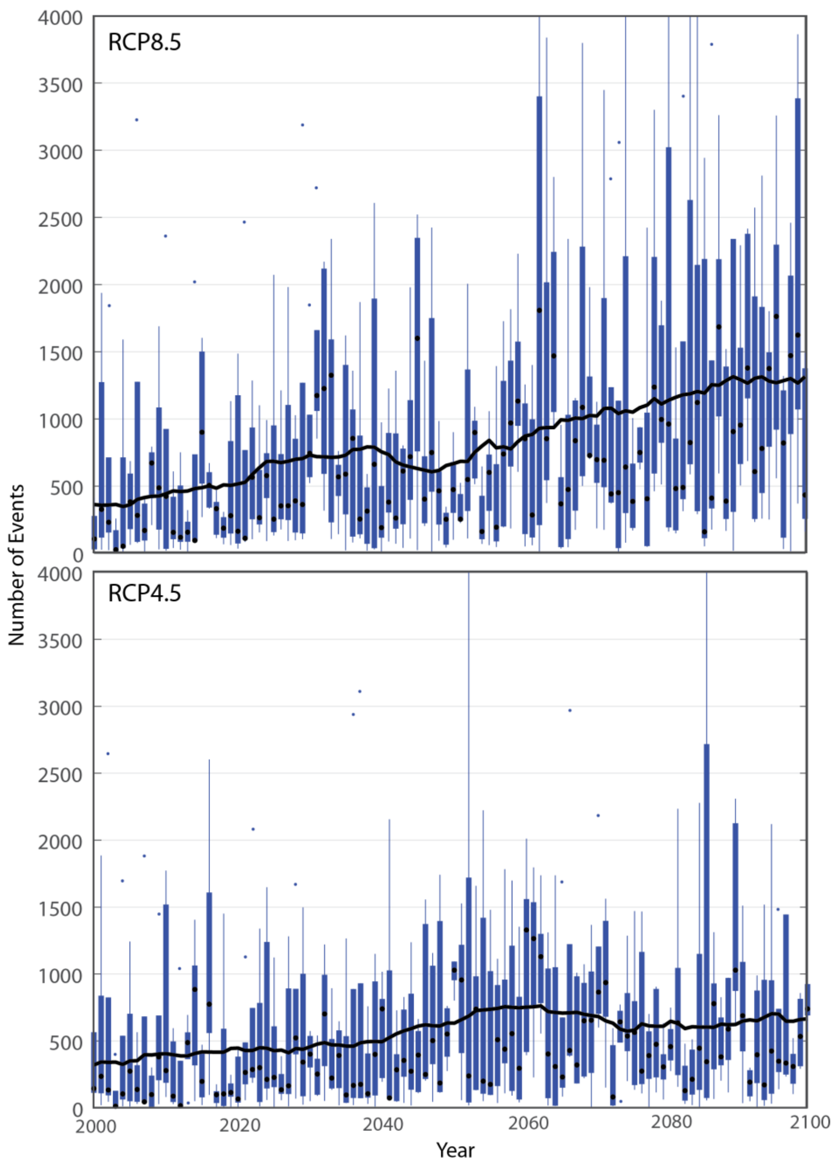


Figure 11: Percent change in national electricity demand

Values across RCPs and the five GCMs are shown relative to a control scenario without climate change for the year 2050 under two electric power sector models (GCAM for 2050 and 2090; and ReEDS for 2090).

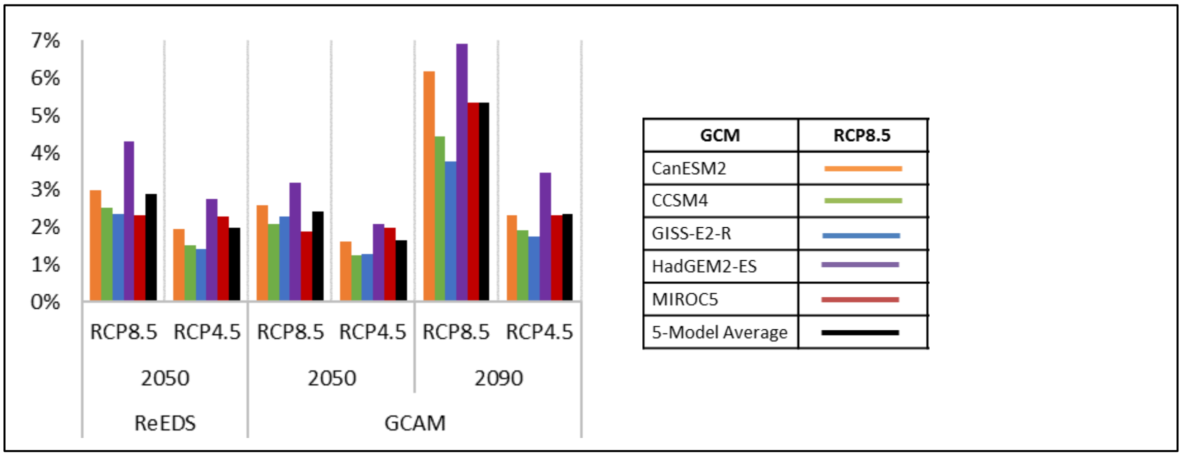
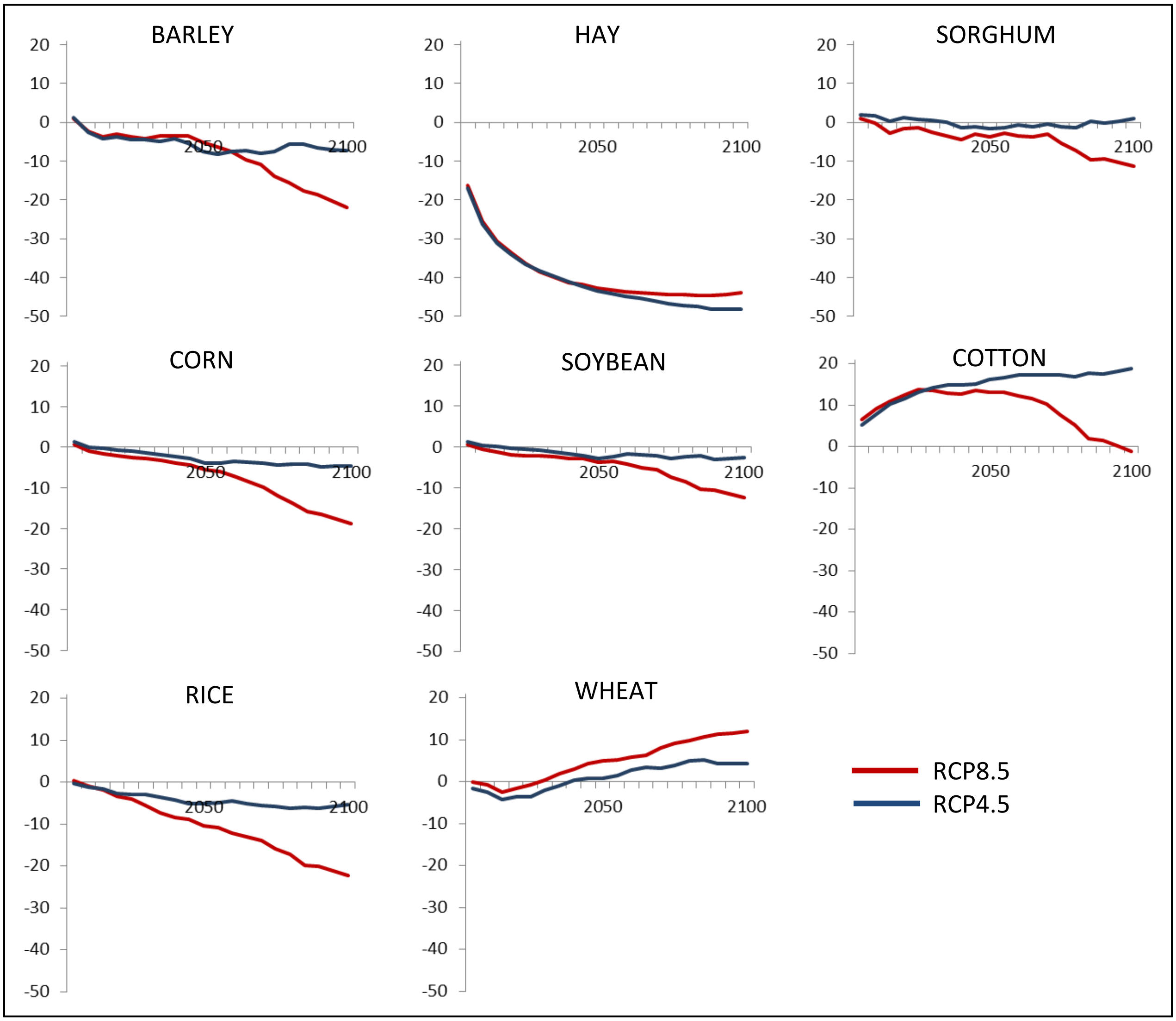


Figure 12: Projected percent change in crop yields for the contiguous United States

Results shown represent the average of the five GCMs under RCP8.5 and RCP4.5 compared to the reference period (1986-2005). Results are weighted averages of the individual irrigated and rainfed values from the EPIC crop simulation model.



5. Tables of the Supplementary Information

Table 1: CMIP5 GCMs used in the analyses of this paper

Center (Modeling Group)	Model Acronym	Availability		References
		LOCA	SNAP	
Canadian Centre for Climate Modeling and Analysis	CanESM2	X		Von Salzen et al. 2013[35]
National Center for Atmospheric Research	CCSM4	X	X	Gent et al. 2011[36] Neale et al. 2013[37]
NASA Goddard Institute for Space Studies	GISS-E2-R	X	X	Schmidt et al. 2006[38]
Met Office Hadley Centre	HadGEM2-ES	X		Collins et al., 2011[39] Davies et al. 2005[40]
Atmosphere and Ocean Research Institute, National Institute for Environmental Studies, and Japan Agency for Marine-Earth Science and Technology	MIROC5	X		Watanabe et al. 2010[41]

Table 2: Global mean sea level rise in 2100 with scenario weights

Global Mean Sea Level Rise in 2100 (cm)	RCP8.5		RCP4.5	
	Exceedance Probability	Scenario Weight	Exceedance Probability	Scenario Weight
30	0.9997	0.0069	0.9814	0.0948
50	0.9607	0.4064	0.7296	0.7197
100	0.1670	0.5464	0.0330	0.1746
150	0.0133	0.0352	0.0045	0.0087
200	0.0026	0.0038	0.0012	0.0014
250	0.0009	0.0013	0.0005	0.0008

Table 3: Expanded summary of sectoral impact analyses of the CIRA2.0 project (expanded from Table 1 of main text)

Sector and Key Reference	Summary of Approach	Name(s) of Sectoral Model(s)*	Reference Period**	Base Resolution of Modeling***	Socioeconomic Change	Economic Valuation	Adaptation Simulated
HEALTH							
Air Quality[42]	Future ozone concentrations and resulting number of premature deaths [P] ±	Weather Research and Forecasting (WRF)[43], Community Multiscale Air Quality (CMAQ)[44], Benefits Mapping and Analysis Program – Community Edition (BenMAP-CE)[45]	1995-2005	Atmospheric chemistry at 36km grid cells (dynamically downscaled via WRF); health effects at county-scale	Dose-response functions applied to Integrated Climate and Land Use Scenarios version 2 (ICLUSv2) projected population; income-adjusted VSL	Value of a statistical life (VSL)	Air quality management adaptation scenarios were not modeled
Aeroallergens[46]	Change in oak pollen season length, concentrations, and emergency department visits for asthmatics [E]	BenMAP-CE	1994-2010	0.5 degree grid cells in the Northeast, Southeast, and Midwest	Dose-response functions applied to ICLUSv2 projected population	Emergency department cost-per-visit adjusted for inflation	No additional adaptations beyond those represented in the observed period
Extreme Temperature Mortality[47]	Number of premature deaths attributable to extreme hot and cold temperatures [E]	BenMAP[48] was used to develop estimates of the annual all-age mortality rate in the study cities	1989-2000	49 major U.S. cities	Mortality functions[49] applied to ICLUSv2 projected population; income-adjusted VSL	VSL	Adaptations within observed period plus adjusted mortality relationships to include higher levels of adaptive capacity
Labor[50]	Lost labor supply hours due to changes in hot and cold temperature, including extreme temperatures [E]	Dose-response functions for temperature and hours worked (American Time Use Survey)	2003-2007	Counties	Number of workers adjusted by ICLUSv2 projected population; wages scaled by economic growth	Lost Wages	No additional adaptations beyond those represented in the observed period
West Nile Virus[51]	Impact of temperature on number of West Nile Neuroinvasive Disease cases [E]	Health Impact Function for temperature and incidence rate exceedance[52]	1986-2005	Counties, scaled to states or NCA4 regions for presentation	Mortality functions applied to ICLUSv2 projected population; income-adjusted VSL	VSL and hospitalization costs	No additional adaptations beyond those represented in the observed period
Harmful Algal Blooms[53]	Change in occurrence and severity of cyanobacterial harmful algal blooms [P]	Climate runoff model version 2 (CLIRUN-II)[54]; water demand; US Basins[55]; QUALIDAD[56] water quality model	1986-2005 (control scenario)	Eight-digit hydrologic unit codes (HUCs), scaled to four-digit HUCs for presentation	Number of recreational visits adjusted by ICLUSv2 projected population	Lost consumer surplus from reservoir recreation in 279 reservoirs	No potential physiological or ecological adaptations simulated

Sector and Key Reference	Summary of Approach	Name(s) of Sectoral Model(s)*	Reference Period**	Base Resolution of Modeling***	Socioeconomic Change	Economic Valuation	Adaptation Simulated
INFRASTRUCTURE							
Roads[57]	Vulnerability of paved, unpaved, and gravel roads to changes in temperature, precipitation, and freeze-thaw cycles [P]	Infrastructure Planning Support System (IPSS)[58]	1950-2013	0.5 degree grid cells	No assumed expansion of road network	Costs of repair or rehabilitation	Reactive or proactive repair or rehabilitation costs to maintain level of service
Bridges[59]	Vulnerability of non-coastal bridges to changes in peak water flow [P]	USDA Natural Resources Conservation Service TR-20 model	1980-2009	Four-digit HUCs, scaled to eight-digit HUCs for presentation	No assumed expansion of bridge network	Costs of repair or rehabilitation	Costs of proactive maintenance and repairs to maintain level of service
Rail[60]	Vulnerability of the Class 1 rail network (passenger and freight) to changes in temperature [P]	IPSS	1950-2013	0.5 degree grid cells	Freight volume scaled by change in economic growth, passenger volume scaled by ICLUSv2 projected population. No assumed expansion of rail network	Costs of delays and sensor installation	Costs of delays (reduced speed and traffic) to railroad companies and to public, and proactive adaptation costs to install sensors
Alaska Infrastructure[61]	Vulnerability of roads, buildings, airports, railroads, and pipelines to changes in permafrost thaw, freeze-thaw cycles, precipitation, and flooding [P]	IPSS	1950-1999	Multiple levels based on type, with spatial aggregation to Burroughs	No assumed expansion of infrastructure networks	Costs of repair, rehabilitation, or reconstruction	Reactive and proactive adaptation expenditures to maintain level of service
Urban Drainage[62]	Change in urban drainage volume from changes in rainfall intensity and runoff [P]	Storm Water Management Model (SWMM)[63]	1979-2008	100 major U.S. cities	No assumed expansion of infrastructure network	Construction costs of best management practices (e.g., bioswales)	Proactive adaptation costs to implement stormwater best management practices
Coastal Property[64,65]	Vulnerability of on-shore property to sea level rise and storm surge [P]	National Coastal Property Model (NCPM)	Simulation starts from year 2000 shoreline	Census tracts of coastal areas in the contiguous U.S.	Property values scaled by changes in income. No assumed expansion of coastal floodplain development	Value of abandoned property and costs of protection	Responses include abandonment, property elevation, beach nourishment, and seawall construction.

Sector and Key Reference	Summary of Approach	Name(s) of Sectoral Model(s)*	Reference Period**	Base Resolution of Modeling***	Socioeconomic Change	Economic Valuation	Adaptation Simulated
ELECTRICITY							
Electricity Demand and Supply[66]	Changes in electricity demand and supply (including hydropower generation) in response to changes in temperature and flow [P]	Regional Electricity Deployment System Model (ReEDS)[67]; Global Change Assessment Model (GCAM)[68]	Control scenario (population growth, no climate)	134 balancing areas in ReEDS, state-level in GCAM	Changes in electricity demand are projected based on changes in population and economic growth (ICLUSv2)	Electric power system costs (capital, O&M, fuel costs)	Changes in cooling and heating demands for residences and buildings
WATER RESOURCES							
Inland Flooding[69]	Changes in frequency of 100-year riverine flooding events[70] [P]	Variable infiltration capacity (VIC) hydrologic model[71]	2001-2020	57,000 stream segments of the contiguous U.S.	No assumed expansion of development in the floodplain; damages are not scaled by changes in income.	Damages to assets (e.g., buildings) located in floodplains based on USACE and FEMA depth-damage functions	Adaptation responses not modeled
Water Quality[72]	Changes in river, lake, and reservoir water quality based on modeled temperature, dissolved oxygen, total nitrogen, total phosphorus [P]	Hydrologic and Water Quality System (HAWQS)[73]; Soil and Water Assessment Tool (SWAT); US Basins[74]	1986-2005	Eight-digit HUCs, scaled to Level-III Ecoregions	Point-source loadings, users/non-users, and persons per household scaled by ICLUSv2 projected population	Willingness to pay to offset changes in water quality index	Water allocated to different sectors based on available supply
Municipal and Industrial Water Supply[75]	Changes in water supply to meet municipal indoor, municipal outdoor, and industrial water demands [P]	Water Supply Stress Index (WaSSI)[76] Ecosystem Services Model (USDA); US Basins	Control scenario (population growth and per capita water use, no climate)	Eight-digit HUCs, scaled to four-digit HUCs for presentation	Changes in electricity demand are projected based on changes in population (ICLUSv2)	Consumer welfare	Water allocated to different sectors based on available supply
Winter Recreation[77]	Changes in snowpack and downhill skiing/ snowboarding, cross-country skiing, and snowmobiling visits [P]	Utah Energy Balance (UEB) model[78]	1986-2005	247 downhill, cross-country, and snowmobiling locations	Visitors scaled by ICLUSv2 projected population	Lost recreation (lift ticket and entry prices)	Snow-making included as a response

Sector and Key Reference	Summary of Approach	Name(s) of Sectoral Model(s)*	Reference Period**	Base Resolution of Modeling***	Socioeconomic Change	Economic Valuation	Adaptation Simulated
AGRICULTURE							
Agriculture[79]	Impacts of changing climate conditions on yields of major U.S. crops (e.g., corn, soybean, wheat, alfalfa hay, cotton) [P]	Environmental Policy Integrated Climate (EPIC)[80] model; Forest and Agricultural Sector Optimization Model with Greenhouse Gases (FASOM-GHG)[81]	1986-2005	Crop-specific production locations in the National Resource Inventory. Welfare results based on 5-region version of FASOM model	Demands are projected based on changes in population and economic growth (ICLUSv2)	Producer and consumer welfare	Landowners change crop mix, production practices, and land allocation in response to yield changes
ECOSYSTEMS							
Coral Reefs[82]	Percent change in shallow coral reef cover [P]	Coral Mortality and Bleaching Output (COMBO)[83]	2010	1-degree grid cells covering coastal waters off Hawaii, South Florida, and Puerto Rico	Number of visitors scaled by ICLUSv2 projected population	Lost recreational value	Autonomous adaptation by coral types
Shellfish[84]	Ocean acidification effect on oyster, scallop, geoduck, quahog, and clam growth rates; and shellfish supply [E]	Consumer demand model	2010	Coastal areas of NCA4 Regions	Number of consumers scaled by ICLUSv2 projected population	Consumer welfare	Consumers switch shellfish purchases based on changes in demand
Freshwater Fish[85,86]	Change in spatial distribution of suitable habitat for coldwater, warmwater, and rough fish species [P]	Impacts of habitat change on number of fishing days and the value of recreational fishing	2011	Eight-digit HUCs	Number of anglers scaled by ICLUSv2 projected population	Lost recreational value	Anglers shift target fish guilds based on proximity
Wildfire[87,88]	Change in terrestrial ecosystem vegetative cover and acres burned on non-agricultural, undeveloped lands [P]	MC2 dynamic global vegetation model (DGVM)[89,90]; Alaska Frame-Based Ecosystem Code (ALFRESCO)[91]	1986-2005	0.06-degree grid cells	Not applicable	Response costs	Only wildfires that occur despite endogenous fire suppression tactics are quantified and valued

* Not all sectoral models have common names; where available these are provided.

** Defined as the historic climate reference period modeled in the five GCMs and used as inputs to these sectoral models. Where possible, a reference period of 1986-2005, or a reference period that includes part or all of this time period, was used in sectoral models; however, methodological and data constraints prevented universal application.

*** Scope of analysis comprehensively covers the contiguous United States unless stated otherwise.

± Studies primarily using process-based models are noted with [P]; those using primarily econometric models are noted with [E]

Table 4: Projected annual physical impacts of climate change across sectors at the national scale

Positive numbers represent damages due to climate change, while negative numbers represent a reduction in damages compared to the reference period. Values may not sum due to rounding. With the exception of Air Quality, upper and lower bounds are based on values across the GCMs. In general, results do not include the effect of adaptation, which was shown in some sectors to reduce physical effects (see Table 2 of main paper). Only some of the 22 sectoral analyses produced discrete physical metric estimates; see Table 3. Additional results can be found in the CIRA2.0 Technical Documentation.[92]

		2050			2090		
		RCP8.5	RCP4.5	Difference	RCP8.5	RCP4.5	Difference
HEALTH							
Air Quality: # Deaths		790 (420 to 1,200)	550 (300 to 810)	240 (NA)	1,700 (920 to 2,500)	1,200 (630 to 1,700)	500 (NA)
Aeroallergens: Emergency Department visits (thousands)		1.2 (0.068 to 1.8)	0.90 (0.19 to 1.6)	0.30 (-0.12 to 0.83)	2.5 (0.87 to 3.5)	1.1 (-0.081 to 1.9)	1.4 (0.95 to 1.9)
Extreme Temperature Mortality:	# Deaths from Heat	3,400 (2,300 to 5,900)	2,600 (1,700 to 3,900)	880 (170 to 2,000)	9,300 (5,400 to 13,000)	3,900 (2,400 to 7,400)	5,400 (2,800 to 8,100)
	# Deaths from Cold	-33 (-49 to -10)	-33 (-49 to -10)	0 (-17 to 30)	-53 (-58 to -48)	-33 (-51 to -6)	20 (4 to 46)
Labor: Lost Labor Hours (millions)		880 (500 to 1,400)	700 (380 to 1,100)	180 (-24 to 290)	1,900 (1,000 to 2,700)	970 (620 to 1,500)	910 (420 to 1,300)
West Nile Virus: # Cases (thousands)		1.3 (0.92 to 1.8)	1.0 (0.72 to 1.4)	0.23 (0.19 to 0.33)	3.3 (2.0 to 4.6)	1.7 (1.2 to 2.4)	1.6 (0.81 to 2.2)
Harmful Algal Blooms: # Days above 100k cells/mL		9.2 (5.4 to 15)	8.4 (6.8 to 13)	0.71 (-0.88 to 2.3)	15 (6.5 to 24)	9 (2.7 to 15)	5.7 (2.2 to 11)
INFRASTRUCTURE							
Roads		Specific physical impact metrics are not modeled; IPSS model estimates incremental change in expenditures under projected climate change					
Bridges: # Vulnerable Bridges (thousands)		4.6 (3.3 to 6.1)	2.5 (1.6 to 3.5)	2.1 (0.88 to 4.1)	6.0 (2.4 to 8.8)	5.0 (3.1 to 6.3)	0.99 (-0.67 to 3.2)
Rail		Specific physical impact metrics are not modeled; IPSS model estimates incremental change in expenditures under projected climate change					
Alaska Infrastructure							
Urban Drainage		Specific physical impact metrics are not modeled; SWMM model estimates proactive adaptation costs per square mile for 100 U.S. cities					

		2050			2090		
		RCP8.5	RCP4.5	Difference	RCP8.5	RCP4.5	Difference
Coastal Property		Specific physical impact metrics are not modeled; NCPM model estimates economic impacts of adaptation decisions					
ELECTRICITY							
Electricity Demand & Supply	Heating Degree Days	-845 (-1056 to -560)	-667 (-867 to -349)	-178 (-271 to -124)	-1527 (-1872 to -1018)	-863 (-1133 to -421)	-665 (-738 to -596)
	Cooling Degree Days	771 (587 to 1114)	584 (394 to 840)	187 (78 to 274)	1602 (1027 to 2243)	814 (516 to 1257)	789 (510 to 986)
WATER RESOURCES							
Inland Flooding		Specific physical impact metrics are not modeled; VIC model projects runoff and streamflow to calculate asset damages					
Water Quality		Changes to Water Quality Index are not nationally aggregated; see Fig. 9					
Municipal and Industrial Water Supply		Specific physical impact metrics are not modeled; welfare losses are calculated based on projected changes to water demand and supply					
Winter Recreation: Lost Visits (millions)		12 (-3.3 to 20)	-4.5 (-10 to -1.1)	16 (-2.2 to 30)	28 (4.7 to 38)	2.5 (-18 to 14)	25 (23 to 30)
AGRICULTURE							
Agriculture: % Decrease in Corn Yields (example crop)		5.8% (-1.6% to 17%)	3.6% (-3.8% to 12%)	2.2% (-6.3% to 6.6%)	17% (6.7% to 28%)	4.5% (-3.1% to 15%)	13% (8.0% to 22%)
ECOSYSTEMS							
Coral Reefs	**HI:** % Lost Cover	70% (11% to 97%)	64% (7.3% to 94%)	5.6% (-11% to 17%)	96% (88% to 98%)	79% (26% to 97%)	16% (-1.2% to 63%)
	FL: % Lost Cover	95% (93% to 97%)	94% (89% to 96%)	1.6% (-1.1% to 8.5%)	97% (95% to 98%)	96% (95% to 97%)	0.57% (0.10% to 1.3%)
	PR: % Lost Cover	93% (89% to 95%)	93% (85% to 96%)	-0.80% (-6.7% to 9.7%)	95% (92% to 98%)	97% (96% to 97%)	-1.4% (-3.9% to 0.88%)
Shellfish: %Decrease in Oyster Supply (example species)		23% (22% to 24%)	16% (14% to 17%)	7.1% (5.2% to 8.1%)	48% (46% to 50%)	22% (20% to 24%)	25% (24% to 26%)
Freshwater Fish: Lost Coldwater Fishing Days (millions)		67 (54 to 80)	62 (47 to 75)	5.4 (3.3 to 6.8)	90 (73 to 100)	67 (55 to 80)	23 (18 to 29)
Wildfire: Acres Burned (millions)		-0.55 (-1.9 to 0.50)	-1.8 (-2.6 to -0.69)	1.2 (0.093 to 2.1)	-0.36 (-1.9 to 0.38)	-2.1 (-2.8 to -1.5)	1.7 (0.49 to 2.3)

Notes:
"NA" indicates analyses where GCM-specific results are not available.
Air Quality: Mean and upper/lower bounds based on confidence intervals from the BenMAP-CE model.
Harmful Algal Blooms: Range and mean values based on combined high and low growth scenarios.
Wildfire: Results represent changes in both the contiguous United States and Alaska.

Table 5: Projected annual economic impacts of climate change across sectors at the national scale

Positive numbers represent damages due to climate change, while negative numbers represent a reduction in damages compared to the reference period. Values may not sum due to rounding. With the exception of Air Quality, upper and lower bounds are based on values across the GCMs. Values shown in millions of undiscounted $2015. In general, results do not include the effect of adaptation, which was shown in some sectors to reduce damages (see Table 2 of main paper).

	2050			2090		
	RCP8.5	**RCP4.5**	**Difference**	**RCP8.5**	**RCP4.5**	**Difference**
HEALTH						
Air Quality	$9,800 ($880 to $28,000)	$6,900 (-$900 to $21,000)	$2,900 (NA)	$26,000 (-$2,200 to $78,000)	$18,000 ($1,600 to $51,000)	$8,000 (NA)
Aeroallergens	$0.59 ($0.033 to $0.90)	$0.44 ($0.092 to $0.80)	$0.14 (-$0.059 to $0.40)	$1.2 ($0.43 to $1.7)	$0.52 (-$0.040 to $0.93)	$0.70 ($0.47 to $0.91)
Extreme Temp. Mortality *(net of heat and cold)*	$43,000 ($28,000 to $73,000)	$32,000 ($21,000 to $48,000)	$11,000 ($2,100 to $25,000)	$140,000 ($82,000 to $200,000)	$59,000 ($37,000 to $110,000)	$82,000 ($42,000 to $120,000)
Labor	$44,000 ($25,000 to $70,000)	$35,000 ($19,000 to $56,000)	$9,000 (-$1,200 to $15,000)	$160,000 ($87,000 to $220,000)	$80,000 ($52,000 to $120,000)	$75,000 ($35,000 to $110,000)
West Nile Virus	$1,100 ($780 to $1,500)	$870 ($610 to $1,200)	$200 ($160 to $280)	$3,300 ($2,000 to $4,700)	$1,800 ($1,200 to $2,500)	$1,600 ($820 to $2,200)
Harmful Algal Blooms	$79 ($42 to $170)	$64 ($30 to $150)	$15 (-$17 to $49)	$200 ($130 to $390)	$110 ($54 to $230)	$89 ($22 to $180)
INFRASTRUCTURE						
Roads	$9,500 ($2,800 to $23,000)	$6,500 ($2,700 to $16,000)	$2,900 (-$680 to $7,200)	$20,000 ($7,000 to $37,000)	$8,100 ($3,300 to $20,000)	$12,000 ($3,700 to $17,000)
Bridges	$1,700 ($950 to $2,200)	$1,500 ($1,100 to $1,700)	$220 (-$140 to $650)	$1,000 ($670 to $1,300)	$510 ($310 to $740)	$490 ($270 to $910)
Rail	$1,800 ($1,300 to $2,200)	$1,500 ($1,100 to $1,800)	$270 (-$17 to $410)	$5,500 ($4,000 to $6,600)	$3,500 ($2,400 to $4,400)	$2,000 ($1,600 to $2,300)
Alaska Infrastructure	$180 ($170 to $180)	$120 ($110 to $130)	$60 ($55 to $66)	$170 ($130 to $220)	$82 ($80 to $84)	$92 ($49 to $140)
Urban Drainage	$3,700 ($2,100 to $4,600)	$4,300 ($3,500 to $4,900)	-$600 (-$2,100 to $63)	$5,600 ($3,300 to $7,000)	$4,100 ($2,900 to $5,900)	$1,500 (-$110 to $3,200)
Coastal Property	$75,000 (NA)	$69,000 (NA)	$6,800 (NA)	$120,000 (NA)	$92,000 (NA)	$26,000 (NA)
ELECTRICITY						

	2050			2090		
	RCP8.5	RCP4.5	Difference	RCP8.5	RCP4.5	Difference
Electricity Demand and Supply	$3,200 ($2,700 to $4,200)	$2,000 ($1,400 to $2,600)	$1,200 ($390 to $1,600)	$9,200 ($6,500 to $11,000)	$3,400 ($2,300 to $5,000)	$5,800 ($3,500 to $7,600)
WATER RESOURCES						
Inland Flooding	$5,100 (NA)	$4,300 (NA)	$770 (NA)	$8,100 (NA)	$4,300 (NA)	$3,800 (NA)
Water Quality	$1,900 ($1,300 to $2,800)	$1,500 ($1,100 to $2,200)	$390 ($260 to $610)	$4,600 ($3,200 to $5,700)	$3,000 ($1,700 to $4,200)	$1,600 ($1,100 to $2,200)
Municipal and Industrial Water Supply	$120 ($26 to $240)	$120 ($27 to $240)	$1.4 (-$85 to $89)	$320 ($190 to $640)	$210 (-$9.3 to $410)	$100 (-$32 to $230)
Winter Recreation	$780 (-$440 to $1,500)	-$430 (-$890 to -$38)	$1,200 (-$400 to $2,400)	$2,000 ($28 to $2,900)	-$130 (-$1,900 to $830)	$2,200 ($1,900 to $2,500)
AGRICULTURE						
Agriculture	$8.0 ($6.7 to $11)	$7.7 ($6.4 to $10)	$0.22 (-$1.7 to $1.2)	$12 ($11 to $13)	$11 ($9.3 to $13)	$1.3 (-$0.33 to $2.0)
ECOSYSTEMS						
Coral Reefs (all sites)	$3,400 ($1,800 to $4,200)	$3,200 ($1,600 to $4,100)	$200 (-$330 to $720)	$4,100 ($3,800 to $4,200)	$3,600 ($1,900 to $4,100)	$500 (-$31 to $1,900)
Shellfish	$9.1 ($3.7 to $14)	$6.1 ($2.1 to $9.0)	$3.0 ($1.1 to $5.1)	$23 ($8.9 to $35)	$10 ($3.4 to $15)	$13 ($5.4 to $20)
Freshwater Fish	$1,900 (-$430 to $4,600)	$1,800 ($740 to $3,100)	$35 (-$1,200 to $1,500)	$3,100 (-$410 to $5,500)	$1,700 (-$300 to $3,700)	$1,400 (-$110 to $2,100)
Wildfire	-$67 (-$230 to $62)	-$150 (-$280 to -$5.6)	$82 (-$11 to $180)	-$110 (-$340 to $8.6)	-$250 (-$340 to -$170)	$140 (-$6.9 to $250)

Notes:
”NA” indicates analyses where GCM-specific results are not available.
Air Quality: Mean and upper/lower bounds based on confidence intervals from the BenMAP-CE model.
Harmful Algal Blooms: Range and mean values based on combined high and low growth scenarios.
Urban Drainage: Values represent results under the 50-year storm.
Coastal Property: Costs with no adaptation. See Modeling Framework section for a description of SLR uncertainty.
Electricity Demand and Supply: Values represent power system supply costs. Results are from the GCAM power sector model only.
Water Quality: Range and mean values based on combined results from US Basins and HAWQS.
Freshwater Fish: Values represent impacts to all three fishing guilds (coldwater, warmwater, and rough)
Wildfire: Results represent changes in both the contiguous United States and Alaska.

Table 6: Projected annual physical impacts in 2090 under RCP8.5 across sectors and regions of the contiguous United States

Positive numbers represent damages due to climate change, while negative numbers represent a reduction in damages compared to the reference period. Except for Air Quality, upper and lower bounds are based on values across the GCMs. In general, results do not include the effect of adaptation, which was shown in some sectors to reduce damages (see Table 2 of main paper). See Table 4 for physical impacts to Alaska Infrastructure and Coral Reefs in Hawaii and Puerto Rico (both of which are outside of the contiguous United States). Values may not sum due to rounding.

	Northeast	Southeast	Midwest	Northern Plains	Southern Plains	Southwest	Northwest
HEALTH							
Air Quality: # Deaths	670 (360 to 980)	-72 (-38 to -100)	910 (490 to 1,300)	42 (22 to 61)	-37 (-54 to -20)	110 (59 to 160)	93 (50 to 140)
Aeroallergens: Emergency Department visits (thousands)	1,100 (560 to 1,300)	730 (97 to 1,200)	720 (210 to 1,100)	-	-	-	-
Extreme Temperature Mortality: # deaths (net heat and cold)	2,300 (1,100 to 3,400)	1,600 (910 to 2,100)	2,000 (1,300 to 3,300)	-	1,300 (960 to 1,500)	2,000 * (1,200 to 3,000)	-0.38 * (-1.1 to 0.94)
Labor: Lost Labor Hours (millions)	230 (100 to 360)	570 (340 to 820)	400 (180 to 640)	31 (14 to 42)	330 (210 to 440)	280 (200 to 350)	23 (12 to 40)
West Nile Virus: # Cases (thousands)	490 (280 to 690)	1,100 (570 to 1,800)	450 (260 to 690)	330 (150 to 480)	450 (350 to 530)	420 (390 to 440)	11 (11 to 11)
Harmful Algal Blooms: # Days above 100k cells/mL	36 (22 to 47)	5.2 (3.2 to 10)	7.5 (1.7 to 17)	15 (3.0 to 28)	15 (4.3 to 32)	15 (-0.60 to 26)	1.1 (-0.01 to 3.0)
INFRASTRUCTURE							
Roads	Specific physical impact metric not estimated; see Table 4						
Bridges: # Vulnerable Bridges (thousands)	570 (370 to 880)	1,600 (780 to 2,300)	1,700 (510 to 2,900)	410 (190 to 630)	1,100 (160 to 1,700)	360 (200 to 530)	200 (76 to 290)
Rail	Specific physical impact metric not estimated; see Table 4						
Urban Drainage							
Coastal Property							
ELECTRICITY							

		Northeast	Southeast	Midwest	Northern Plains	Southern Plains	Southwest	Northwest
Electricity Demand & Supply	Heating Degree Days	0.6 (0.6 to 0.7)	0.6 (0.5 to 0.7)	0.7 (0.6 to 0.8)	0.7 (0.6 to 0.8)	0.6 (0.5 to 0.7)	0.6 (0.5 to 0.7)	0.7 (0.6 to 0.8)
	Cooling Degree Days	2.6 (2.0 to 3.2)	1.9 (1.6 to 2.1)	2.5 (2.0 to 3.0)	2.5 (2.0 to 2.9)	1.7 (1.5 to 1.9)	1.9 (1.7 to 2.3)	4.3 (2.7 to 6.0)
WATER RESOURCES								
Inland Flooding		Specific physical impact metric not estimated; see Table 4						
Water Quality								
Municipal and Industrial Water Supply								
Winter Recreation: Lost Visits (millions)		15 (11 to 17)	0.88 (0.57 to 1.1)	6.4 (4.0 to 7.5)	0.54 (-1.2 to 1.4)	-	1.5 (-10 to 6.5)	3.6 (0.37 to 5.5)
AGRICULTURE								
Agriculture: % Decrease in Corn Yields (example crop)		6.2% (-1.5% to 20%)	22% (14% to 33%)	18% (7.7% to 30%)	12% (-1.3% to 17%)	23% (13% to 30%)	-3.7% (-8.8% to -0.19%)	0.42% (-10% to 10%)
ECOSYSTEMS								
Coral Reefs: % lost cover		-	97% (95% to 98%)	-	-	-	-	-
Shellfish: %Decrease in Oyster Supply (example species)		50% (48% to 53%)	46% (44% to 48%)	-	-	-	-	52% (49% to 55%)
Freshwater Fish: Lost Coldwater Fishing Days (millions)		35 (34 to 36)	15 (11 to 17)	12 (12 to 13)	1.2 (0.75 to 2.0)	Value too small to differentiate from zero	18 (12 to 26)	8.1 (2.4 to 15)
Wildfire: Acres Burned (millions)		1,800 (510 to 3,200)	76 (-67 to 220)	-76 (-180 to 41)	-85 (-260 to 55)	140 (-8.1 to 240)	-840 (-1,700 to -56)	-15 (-220 to 110)

Notes*:*

[-] Impact not relevant to, or specifically modeled for, this region.

* These regions contain cities with no heat mortality response function in the historic period, leading to underestimates of the change in future mortality with warming.

Air Quality: Mean and upper/lower bounds based on confidence intervals from the BenMAP-CE model.

Harmful Algal Blooms: Range and mean values based on combined high and low growth scenarios.

Table 7: Projected annual economic impacts in 2050 under RCP8.5 and RCP4.5 across sectors and regions of the contiguous United States
Positive numbers represent damages due to climate change, while negative numbers represent a reduction in damages compared to the reference period. Except for Air Quality, upper and lower bounds are based on values across the GCMs. Values shown in millions of undiscounted $2015. Values may not sum due to rounding. In general, results do not include the effect of adaptation, which was shown in some sectors to reduce damages (see Table 2 of main paper). See Table 5 for values for damages to Alaska Infrastructure and Coral Reefs in Hawaii and Puerto Rico (both of which are outside of the contiguous United States), and for damages to agriculture and shellfish (which were estimated using national market models).

2050 Damages								
		Northeast	**Southeast**	**Midwest**	**Northern Plains**	**Southern Plains**	**Southwest**	**Northwest**
HEALTH								
Air Quality	**RCP8.5**	$2,900 ($260 to $8,200)	$850 ($77 to $2,400)	$4,700 ($420 to $13,000)	$280 ($25 to $810)	$40 ($3.6 to $110)	$770 ($69 to $2,200)	$240 ($22 to $690)
	RCP4.5	$2,500 ($230 to $7,200)	-$500 (-$1,400 to -$45)	$3,700 ($330 to $11,000)	$250 ($23 to $720)	-$53 (-$150 to -$4.7)	$880 ($79 to $2,500)	$65 ($5.8 to $180)
Aero-allergens	**RCP8.5**	$0.24 ($0.078 to $0.40)	$0.18 (-$0.070 to $0.30)	$0.17 ($0.029 to $0.25)	*a*	*a*	*a*	*a*
	RCP4.5	$0.24 ($0.12 to $0.33)	$0.14 (-$0.038 to $0.30)	$0.064 (-$0.17 to $0.28)				
Extreme Temp. Mortality *(net of heat and cold)*	**RCP8.5**	$7,900 ($4,100 to $15,000)	$7,500 ($4,500 to $14,000)	$9,800 ($4,800 to $22,000)	*b*	$6,800 ($3,400 to $10,000)	$11,000 ($5,700 to $20,000)	$41 (-$7.2 to $150)
	RCP4.5	$8,000 ($5,000 to $13,000)	$5,700 ($3,500 to $11,000)	$8,600 ($3,500 to $16,000)		$4,400 ($2,200 to $5,900)	$5,000 ($2,300 to $9,800)	$14 (-$13 to $46)
Labor	**RCP8.5**	$4,600 ($2,200 to $7,200)	$14,000 ($7,000 to $23,000)	$9,800 ($4,800 to $19,000)	$690 ($280 to $1,000)	$8,900 ($5,300 to $13,000)	$6,100 ($4,600 to $7,800)	$350 ($170 to $790)
	RCP4.5	$4,100 ($3,200 to $5,900)	$11,000 ($5,900 to $19,000)	$8,200 ($3,800 to $16,000)	$550 ($190 to $780)	$6,900 ($2,800 to $10,000)	$3,900 ($3,000 to $4,700)	$220 ($87 to $440)

2050 Damages								
		Northeast	**Southeast**	**Midwest**	**Northern Plains**	**Southern Plains**	**Southwest**	**Northwest**
West Nile Virus	**RCP8.5**	$140 ($93 to $190)	$310 ($190 to $540)	$140 ($100 to $210)	$86 ($43 to $120)	$190 ($150 to $210)	$200 ($190 to $210)	$5.5 ($5.3 to $5.6)
	RCP4.5	$110 ($62 to $160)	$230 ($110 to $400)	$110 ($78 to $160)	$67 ($34 to $99)	$160 ($130 to $190)	$190 ($180 to $200)	$5.4 ($5.2 to $5.5)
Harmful Algal Blooms	**RCP8.5**	$8.1 ($0.060 to $19)	$48 ($23 to $91)	$4.2 ($0 to $27)	-$0.86 (-$4.2 to $3.3)	$12 (-$4.1 to $29)	$7.6 ($3.2 to $13)	$0.18 (-$0.050 to $0.69)
	RCP4.5	$5.9 ($0 to $17)	$38 ($7.6 to $78)	$2.7 ($0 to $18)	-$0.94 (-$3.9 to $1.7)	$13 (-$4.7 to $38)	$4.9 ($0.12 to $10)	$0.22 (-$0.069 to $0.73)
INFRASTRUCTURE								
Roads	**RCP8.5**	$1,200 ($260 to $3,200)	$3,100 ($490 to $9,600)	$3,300 ($800 to $7,500)	$580 ($300 to $920)	$420 ($96 to $890)	$490 (-$81 to $1,000)	$360 ($200 to $500)
	RCP4.5	$830 (-$62 to $2,100)	$2,100 ($200 to $6,700)	$2,400 ($1,000 to $5,000)	$420 ($200 to $650)	$370 ($61 to $700)	$240 ($30 to $360)	$210 ($90 to $320)
Bridges	**RCP8.5**	$220 ($170 to $280)	$430 ($260 to $580)	$430 ($200 to $670)	$89 ($55 to $120)	$300 ($110 to $440)	$120 ($68 to $200)	$83 ($48 to $130)
	RCP4.5	$180 ($140 to $230)	$340 ($270 to $430)	$390 ($230 to $500)	$91 ($66 to $120)	$300 ($170 to $410)	$95 ($53 to $120)	$71 ($56 to $86)
Rail	**RCP8.5**	$160 ($120 to $200)	$320 ($250 to $400)	$500 ($390 to $650)	$180 ($130 to $220)	$240 ($180 to $300)	$320 ($240 to $400)	$45 ($33 to $63)
	RCP4.5	$130 ($96 to $170)	$280 ($200 to $340)	$430 ($310 to $530)	$160 ($100 to $190)	$210 ($130 to $260)	$250 ($190 to $310)	$36 ($24 to $57)
Urban Drainage	**RCP8.5**	$280 ($19 to $530)	$1,400 ($1,100 to $1,500)	$440 ($120 to $880)	$21 ($0 to $42)	$950 ($170 to $1,600)	$570 ($170 to $1,100)	$84 ($46 to $130)
	RCP4.5	$240 ($5.6 to $400)	$1,400 ($900 to $2,400)	$330 ($160 to $600)	$42 ($0 to $87)	$1,600 ($670 to $2,400)	$590 ($470 to $810)	$70 ($45 to $93)

2050 Damages								
		Northeast	**Southeast**	**Midwest**	**Northern Plains**	**Southern Plains**	**Southwest**	**Northwest**
Coastal Property	**RCP8.5**	$10,000 (NA)	$60,000 (NA)	-	-	$840 (NA)	$980 (NA)	$250 (NA)
	RCP4.5	$9,700 (NA)	$56,000 (NA)	-	-	$800 (NA)	$970 (NA)	$240 (NA)
ELECTRICITY								
Electricity Demand and Supply	**RCP8.5**	$240 ($160 to $390)	$1,200 ($970 to $1,600)	$460 ($390 to $620)	$16 ($13 to $18)	$570 ($490 to $690)	$520 ($390 to $660)	$160 ($98 to $240)
	RCP4.5	$130 ($74 to $190)	$720 ($400 to $960)	$280 ($200 to $360)	$10 ($7.0 to $18)	$390 ($230 to $540)	$370 ($230 to $470)	$100 ($54 to $150)
WATER RESOURCES								
Inland Flooding	**RCP8.5**	$1,600 (NA)	$1,700 (NA)	$670 (NA)	$58 (NA)	$510 (NA)	$450 (NA)	$100 (NA)
	RCP4.5	$620 (NA)	$1,800 (NA)	$540 (NA)	$74 (NA)	$810 (NA)	$360 (NA)	$130 (NA)
Water Quality	**RCP8.5**	$430 ($260 to $610)	$490 ($320 to $820)	$390 ($220 to $560)	$56 ($33 to $79)	$220 ($98 to $350)	$290 ($140 to $470)	$58 ($18 to $96)
	RCP4.5	$360 ($210 to $520)	$370 ($170 to $590)	$310 ($150 to $480)	$46 ($26 to $74)	$170 ($45 to $270)	$240 ($14 to $370)	$45 (-$5.4 to $80)
Municipal and Industrial Water Supply	**RCP8.5**	$4.9 ($0.050 to $21)	$4.4 ($0.11 to $18)	$29 (-$9.6 to $99)	$0.24 (-$1.8 to $3.6)	$48 ($8.2 to $75)	$31 (-$3.5 to $78)	-$0.44 (-$0.52 to -$0.37)
	RCP4.5	$5.8 ($0.096 to $19)	$4.0 (-$0.048 to $16)	$29 (-$15 to $85)	$3.0 (-$0.25 to $9.2)	$37 ($15 to $68)	$37 ($25 to $68)	-$0.40 (-$0.52 to -$0.26)
Winter Recreation	**RCP8.5**	$720 ($420 to $1,000)	$41 ($19 to $61)	$190 ($43 to $270)	-$27 (-$90 to -$4.4)	-	-$250 (-$780 to $67)	$110 (-$57 to $220)
	RCP4.5	-$86 (-$440 to $130)	-$14 (-$29 to $4.0)	-$26 (-$110 to $47)	-$23 (-$47 to $4.9)	-	-$240 (-$330 to -$58)	-$44 (-$120 to $34)

2050 Damages								
		Northeast	Southeast	Midwest	Northern Plains	Southern Plains	Southwest	Northwest
AGRICULTURE								
Agriculture	Impacts estimated in a national market model.							
ECOSYSTEMS								
Coral Reefs	**RCP8.5**	-	$2,200 ($2,100 to $2,200)	-	-	-	-	-
	RCP4.5	-	$2,100 ($1,900 to $2,200)	-	-	-	-	-
Shellfish	Impacts estimated in a national market model.							
Freshwater Fish	**RCP8.5**	$500 ($290 to $610)	$450 (-$700 to $2,000)	$180 (-$370 to $670)	$18 (-$13 to $37)	$630 ($220 to $880)	$130 (-$130 to $450)	-$42 (-$84 to -$8.6)
	RCP4.5	$580 ($510 to $630)	$450 (-$37 to $1,300)	$180 (-$150 to $620)	$16 ($0.16 to $38)	$500 ($230 to $760)	$150 ($46 to $300)	-$59 (-$100 to -$24)
Wildfire	**RCP8.5**	$6.0 (-$0.37 to $12)	-$1.2 (-$3.6 to $2.4)	$0.52 (-$6.0 to $7.3)	-$9.5 (-$52 to $32)	-$4.6 (-$7.6 to -$2.1)	-$91 (-$210 to -$28)	$22 (-$20 to $110)
	RCP4.5	$5.2 (-$2.6 to $15)	-$0.73 (-$2.6 to $1.8)	-$2.5 (-$7.6 to $5.2)	-$24 (-$69 to $23)	-$3.8 (-$8.3 to -$0.41)	-$120 (-$180 to -$37)	$7.8 (-$16 to $35)
Regional Totals								
	RCP8.5	$31,000 ($26,000 to $44,000)	$93,000 ($81,000 to $120,000)	$31,000 ($22,000 to $58,000)	$2,000 ($1,100 to $2,900)	$21,000 ($12,000 to $30,000)	$21,000 ($15,000 to $33,000)	$1,900 ($1,300 to $2,500)
	RCP4.5	$27,000 ($23,000 to $36,000)	$82,000 ($73,000 to $100,000)	$25,000 ($18,000 to $43,000)	$1,700 ($950 to $2,300)	$17,000 ($11,000 to $22,000)	$13,000 ($9,100 to $19,000)	$1,100 ($860 to $1,500)

2050 Damages								
		Northeast	Southeast	Midwest	Northern Plains	Southern Plains	Southwest	Northwest
	Diff.	$4,000 (-$1,000 to $9,000)	$11,000 ($5,900 to $16,000)	$5,700 (-$3,700 to $15,000)	$400 (-$200 to $830)	$4,000 ($300 to $9,300)	$8,200 ($4,100 to $14,000)	$760 ($350 to $1,100)

[*a*] underlying analysis did not analyze changes to oak pollen concentrations in this region.

[*b*] underlying analysis did not contain cities in the Northern Plains.

[NA] indicates analyses where GCM-specific results are not available.

[-] impact not relevant to this region.

Air Quality: Mean and upper/lower bounds based on confidence intervals from the BenMAP-CE model.

Harmful Algal Blooms: Range and mean values based on combined high and low growth scenarios.

Urban Drainage: Values represent results under the 50-year storm.

Coastal Property: Costs with no adaptation. See Modeling Framework section for a description of SLR uncertainty.

Electricity Demand and Supply: Values represent power system supply costs. Results are from the GCAM power sector model only.

Water Quality: Range and mean values based on combined results from US Basins and HAWQS.

Freshwater Fish: Values represent impacts to all three fishing guilds (coldwater, warmwater, and rough)

Wildfire: Results represent changes in both the contiguous United States and Alaska.

Table 8: Projected annual economic impacts in 2090 under RCP8.5 and RCP4.5 across sectors and regions of the contiguous United States
Positive numbers represent damages due to climate change, while negative numbers represent a reduction in damages compared to the reference period. With the exception of Air Quality, upper and lower bounds are based on values across the GCMs. Values shown in millions of undiscounted $2015. Values may not sum due to rounding. In general, results do not include the effect of adaptation, which was shown in some sectors to reduce damages (see Table 2 of main paper). See Table 5 for values for damages to Alaska Infrastructure and Coral Reefs in Hawaii and Puerto Rico (both of which are outside of the contiguous United States), and for damages to agriculture and shellfish (which were estimated using national market models).

2090 Damages								
		Northeast	**Southeast**	**Midwest**	**Northern Plains**	**Southern Plains**	**Southwest**	**Northwest**
HEALTH								
Air Quality	**RCP8.5**	$10,000 ($910 to $29,000)	-$1,100 (-$3,100 to -$98)	$14,000 ($1,200 to $39,000)	$630 ($57 to $1,800)	-$560 (-$1,600 to -$50)	$1,700 ($150 to $4,800)	$1,400 ($130 to $4,000)
	RCP4.5	$4,700 ($420 to $13,000)	$1,300 ($120 to $3,800)	$8,800 ($790 to $25,000)	$440 ($40 to $1,300)	$1,400 ($120 to $3,800)	$860 ($77 to $2,500)	$450 ($40 to $1,300)
Aero-allergens	**RCP8.5**	$0.52 ($0.27 to $0.66)	$0.36 ($0.048 to $0.57)	$0.35 ($0.10 to $0.55)	*a*	*a*	*a*	*a*
	RCP4.5	$0.23 ($0.071 to $0.37)	$0.10 (-$0.11 to $0.26)	$0.19 (-$0.0012 to $0.38)				
Extreme Temp. Mortality (net of heat and cold)	**RCP8.5**	$35,000 ($16,000 to $52,000)	$25,000 ($14,000 to $33,000)	$31,000 ($19,000 to $50,000)	*b*	$19,000 ($15,000 to $23,000)	$31,000 ($18,000 to $45,000)	-$5.8 (-$16 to $14)
	RCP4.5	$15,000 ($9,500 to $31,000)	$10,000 ($5,300 to $19,000)	$13,000 ($5,100 to $31,000)		$9,400 ($4,300 to $14,000)	$13,000 ($5,800 to $22,000)	$46 ($10 to $120)
Labor	**RCP8.5**	$19,000 ($8,300 to $29,000)	$47,000 ($28,000 to $68,000)	$33,000 ($15,000 to $53,000)	$2,600 ($1,200 to $3,400)	$28,000 ($17,000 to $36,000)	$23,000 ($17,000 to $29,000)	$1,900 ($1,000 to $3,300)
	RCP4.5	$8,300 ($3,800 to $15,000)	$23,000 ($16,000 to $36,000)	$17,000 ($9,400 to $32,000)	$1,300 ($750 to $2,000)	$18,000 ($14,000 to $22,000)	$12,000 ($7,300 to $16,000)	$730 ($260 to $1,800)

2090 Damages								
		Northeast	**Southeast**	**Midwest**	**Northern Plains**	**Southern Plains**	**Southwest**	**Northwest**
West Nile Virus	**RCP8.5**	$500 ($280 to $710)	$1,200 ($590 to $1,800)	$460 ($260 to $700)	$340 ($150 to $490)	$460 ($360 to $540)	$420 ($390 to $450)	$11 ($11 to $12)
	RCP4.5	$210 ($120 to $350)	$450 ($240 to $810)	$210 ($140 to $320)	$150 ($65 to $230)	$340 ($290 to $370)	$390 ($360 to $400)	$11 ($10 to $11)
Harmful Algal Blooms	**RCP8.5**	$28 ($18 to $32)	$96 ($73 to $140)	$27 ($0 to $84)	$0.27 (-$4.8 to $6.1)	$38 ($5.6 to $98)	$6.6 (-$4.5 to $15)	$3.5 (-$0.19 to $16)
	RCP4.5	$15 ($0.48 to $22)	$63 ($38 to $110)	$4.4 ($0 to $25)	-$0.58 (-$5.4 to $4.8)	$20 (-$3.3 to $56)	$7.9 ($2.8 to $12)	$0.15 (-$0.10 to $0.61)
INFRASTRUCTURE								
Roads	**RCP8.5**	$2,400 (-$1.1 to $6,200)	$6,100 ($1,400 to $13,000)	$6,000 ($2,600 to $10,000)	$1,400 ($610 to $2,000)	$1,300 ($630 to $2,300)	$1,700 ($470 to $3,300)	$950 ($580 to $1,400)
	RCP4.5	$1,300 (-$23 to $3,900)	$2,200 ($29 to $6,900)	$3,100 ($730 to $7,200)	$590 ($200 to $950)	$360 ($98 to $630)	$280 ($130 to $510)	$300 ($160 to $450)
Bridges	**RCP8.5**	$120 ($95 to $160)	$300 ($220 to $380)	$270 ($160 to $380)	$42 ($18 to $66)	$180 ($44 to $320)	$54 ($18 to $110)	$31 ($18 to $51)
	RCP4.5	$77 ($40 to $140)	$150 ($120 to $170)	$110 ($52 to $200)	$25 ($14 to $38)	$83 ($6.1 to $170)	$37 ($12 to $65)	$22 ($2.6 to $42)
Rail	**RCP8.5**	$530 ($360 to $640)	$950 ($750 to $1,100)	$1,400 ($1,000 to $1,600)	$570 ($370 to $690)	$690 ($500 to $790)	$1,200 ($860 to $1,500)	$160 ($96 to $230)
	RCP4.5	$320 ($220 to $430)	$620 ($480 to $750)	$940 ($650 to $1,200)	$360 ($190 to $470)	$450 ($330 to $530)	$730 ($470 to $940)	$89 ($42 to $130)
Urban Drainage	**RCP8.5**	$160 ($39 to $250)	$2,200 ($1,400 to $2,800)	$560 ($80 to $840)	$62 ($0 to $130)	$1,900 ($290 to $2,600)	$680 ($250 to $970)	$84 ($61 to $120)
	RCP4.5	$220 ($19 to $790)	$1,300 ($860 to $1,900)	$480 ($41 to $1,200)	$65 ($0 to $110)	$1,300 ($620 to $1,900)	$630 ($240 to $1,200)	$75 ($65 to $83)

2090 Damages								
		Northeast	Southeast	Midwest	Northern Plains	Southern Plains	Southwest	Northwest
Coastal Property	**RCP8.5**	$12,000 (NA)	$99,000 (NA)	-	-	$1,600 (NA)	$1,100 (NA)	$250 (NA)
	RCP4.5	$9,800 (NA)	$79,000 (NA)	-	-	$1,300 (NA)	$790 (NA)	$220 (NA)
ELECTRICITY								
Electricity Demand and Supply	**RCP8.5**	$790 ($390 to $1,200)	$3,300 ($2,400 to $4,200)	$1,200 ($870 to $1,400)	$61 ($42 to $80)	$1,700 ($1,400 to $1,900)	$1,600 ($1,100 to $2,000)	$550 ($270 to $880)
	RCP4.5	$240 ($100 to $520)	$1,200 ($900 to $1,900)	$430 ($220 to $680)	$27 ($9.1 to $42)	$720 ($460 to $900)	$620 ($420 to $770)	$180 ($87 to $280)
WATER RESOURCES								
Inland Flooding	**RCP8.5**	$1,500 (NA)	$3,100 (NA)	$690 (NA)	$61 (NA)	$900 (NA)	$1,500 (NA)	$280 (NA)
	RCP4.5	$950 (NA)	$1,500 (NA)	$830 (NA)	$80 (NA)	$380 (NA)	$410 (NA)	$170 (NA)
Water Quality	**RCP8.5**	$1,000 ($620 to $1,300)	$1,400 ($930 to $1,800)	$750 ($440 to $1,100)	$110 ($69 to $160)	$530 ($400 to $620)	$650 ($350 to $940)	$140 ($60 to $210)
	RCP4.5	$650 ($370 to $940)	$950 ($560 to $1,400)	$420 ($200 to $690)	$66 ($22 to $110)	$350 ($260 to $470)	$460 ($130 to $780)	$90 ($9.7 to $150)
Municipal and Industrial Water Supply	**RCP8.5**	$36 ($1.7 to $81)	$12 (-$3.6 to $32)	$58 (-$39 to $150)	$0.43 (-$7.2 to $12)	$100 ($27 to $190)	$110 ($11 to $200)	-$0.27 (-$0.61 to $0.46)
	RCP4.5	$11 ($0.63 to $30)	$1.1 (-$3.7 to $14)	$57 (-$37 to $110)	$2.1 (-$4.4 to $12)	$63 ($32 to $110)	$79 (-$0.24 to $180)	-$0.33 (-$0.63 to $0.32)
Winter Recreation	**RCP8.5**	$1,100 ($850 to $1,300)	$65 ($42 to $82)	$360 ($230 to $420)	$47 (-$87 to $110)	-	$170 (-$1,000 to $700)	$260 ($27 to $400)

2090 Damages								
		Northeast	**Southeast**	**Midwest**	**Northern Plains**	**Southern Plains**	**Southwest**	**Northwest**
	RCP4.5	$710 ($350 to $1,000)	$29 (-$7.6 to $63)	$180 ($38 to $280)	-$75 (-$160 to -$27)	-	-$1,100 (-$2,000 to -$660)	$76 (-$150 to $240)
AGRICULTURE								
Agriculture	Impacts estimated in a national market model.							
ECOSYSTEMS								
Coral Reefs	**RCP8.5**	-	$2,200 ($2,100 to $2,200)	-	-	-	-	-
	RCP4.5	-	$2,100 ($2,100 to $2,200)	-	-	-	-	-
Shellfish	Impacts estimated in a national market model.							
Freshwater Fish	**RCP8.5**	$630 ($350 to $990)	$1,100 (-$560 to $2,000)	$420 (-$710 to $900)	$66 ($20 to $88)	$690 ($360 to $1,100)	$170 (-$610 to $560)	$34 (-$34 to $120)
	RCP4.5	$500 ($410 to $680)	$280 (-$600 to $1,600)	$270 (-$460 to $660)	$25 (-$1.3 to $40)	$570 ($310 to $830)	$140 (-$94 to $390)	-$56 (-$100 to -$2.9)
Wildfire	**RCP8.5**	$7.9 ($2.3 to $14)	$2.9 (-$2.6 to $8.5)	-$1.1 (-$5.4 to $3.6)	-$22 (-$62 to $11)	$11 (-$0.87 to $21)	-$100 (-$230 to -$35)	-$15 (-$63 to $19)
	RCP4.5	-$1.7 (-$7.5 to $8.1)	-$1.4 (-$3.4 to $1.7)	-$5.0 (-$7.4 to -$1.7)	-$44 (-$72 to $4.6)	-$4.0 (-$7.9 to $1.2)	-$160 (-$200 to -$91)	-$29 (-$61 to $22)
Regional Totals								
	RCP8.5	$85,000 ($51,000 to $120,000)	$190,000 ($150,000 to $230,000)	$91,000 ($54,000 to $140,000)	$5,900 ($3,200 to $7,800)	$56,000 ($40,000 to $71,000)	$65,000 ($43,000 to $85,000)	$6,100 ($4,000 to $8,300)
	RCP4.5	$43,000 ($35,000 to $70,000)	$120,000 ($110,000 to $150,000)	$45,000 ($30,000 to $85,000)	$3,100 ($1,700 to $4,400)	$34,000 ($25,000 to $45,000)	$29,000 ($15,000 to $43,000)	$2,400 ($1,500 to $3,700)

2090 Damages								
		Northeast	Southeast	Midwest	Northern Plains	Southern Plains	Southwest	Northwest
	Diff.	$42,000 ($17,000 to $66,000)	$67,000 ($40,000 to $90,000)	$46,000 ($23,000 to $69,000)	$2,900 ($1,500 to $3,600)	$22,000 ($14,000 to $26,000)	$36,000 ($27,000 to $48,000)	$3,800 ($2,500 to $4,600)

[*a*] underlying analysis did not analyze changes to oak pollen concentrations in this region.

[*b*] underlying analysis did not contain cities in the Northern Plains.

[NA] indicates analyses where GCM-specific results are not available.

[-] impact not relevant to this region.

Air Quality: Mean and upper/lower bounds based on confidence intervals from the BenMAP-CE model.

Harmful Algal Blooms: Range and mean values based on combined high and low growth scenarios.

Urban Drainage: Values represent results under the 50-year storm.

Coastal Property: Costs with no adaptation. See Modeling Framework section for a description of SLR uncertainty.

Electricity Demand and Supply: Values represent power system supply costs. Results are from the GCAM power sector model only.

Water Quality: Range and mean values based on combined results from US Basins and HAWQS.

Freshwater Fish: Values represent impacts to all three fishing guilds (coldwater, warmwater, and rough)

Wildfire: Results represent changes in both the contiguous United States and Alaska.

Table 9: Modeling cross-sector interactions under future climate change with and without constraints for the availability of water for thermo-electric cooling

Projected change in cumulative electric power system costs from ReEDS modeling relative to a control scenario without climate change are shown by region and the national (contiguous U.S.) in millions of discounted (3%) $2015 and percent change (from control). Note that values are cumulative totals, and therefore differ from annual values provided throughout this manuscript. Values represent average of the five GCMs over the 2015-2050 period. Totals may not sum due to rounding.

Region	**Without Constraints**		**With Constraints**		**% Increase in Costs Due to Inclusion of Constraints**
Northeast	$35,954	5.16%	$35,425	5.23%	1.40%
Southeast	$57,497	4.33%	$61,135	4.61%	6.33%
Midwest	$36,843	4.52%	$36,930	4.53%	0.24%
Northern Plains	$2,042	1.36%	$3,662	2.45%	79.34%
Southern Plains	$27,343	4.43%	$29,739	4.82%	8.76%
Southwest	$18,149	3.95%	$19,961	4.34%	9.98%
Northwest	-$6,111	-6.94%	-$6,258	-7.10%	-2.40%
National Total	$170,718	4.13%	$180,596	4.37%	5.79%

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